The magazine of aerospace technology / AUGUST 1959

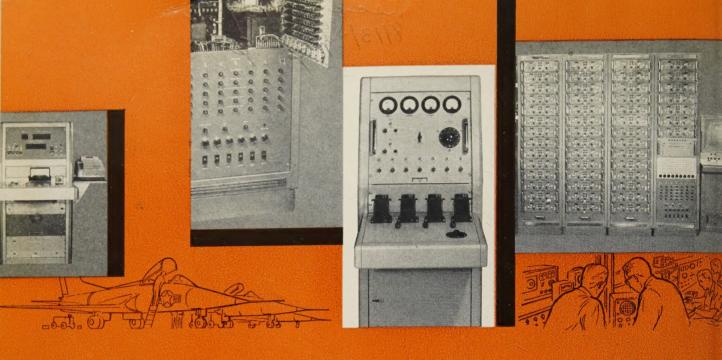
Space agranautics formerly Aviation Age

CHICAGO PROPERTY OF LABORATORIES

Test nose cone gets 20,000-deg F blast

A CONOVER-MAST PUBLICATION

In this issue: The Headache of Missile Stage Separation



TEST EQUIPMENT CAPABILITY...from SMI

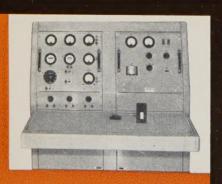
On flight lines and at missile launching sites...in production plants and depot maintenance centers...wherever speed and precision are vital, SMI test equipment capability meets the need with new levels of utility, repeatability...resolution...accuracy.

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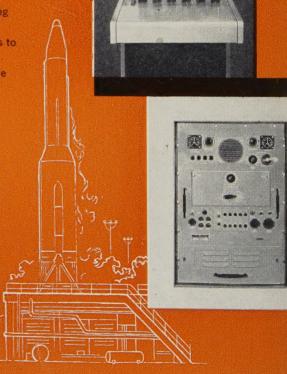
For example, SMI's TS 539 Air Data Computer Test Set is used for checking out elements of the Hughes Aircraft Company MA-1 aircraft and weapon control system. The TS 539 provides both electrical and pneumatic signals to the computer under test, achieving extremely high accuracy by means of electronically controlled force balance sensors. Mach readings are accurate to .7 millimachs and altitude readings within 15 feet at a speed of 1.4 Mach and an altitude of 30,000 feet.

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Engineers: Investigate the opportunities available now at SMI in the fields of aircraft and missile instrument-control systems development.







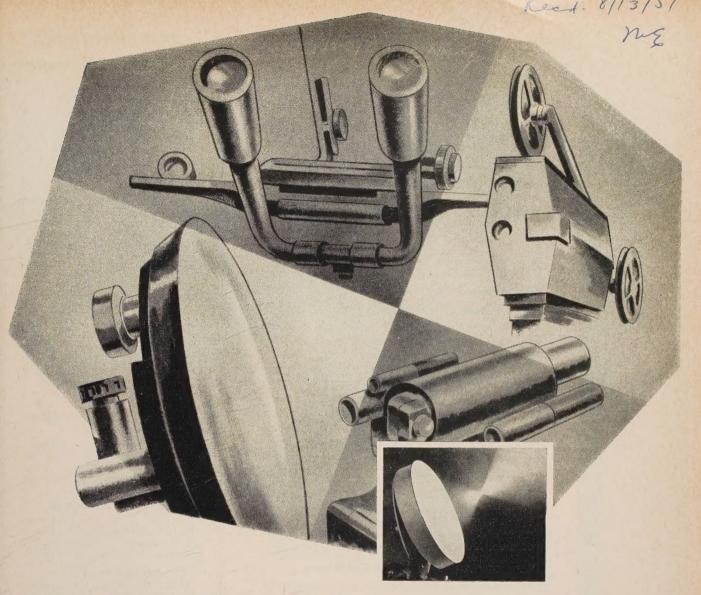


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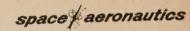
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Hydromatics FLO·BALL valves

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For ground support, motor-operated FLO·BALL valves up to 8" afford great system simplification and throttling ability . . . for temperatures as low as -425° F and pressures up to 3,000 psi.

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cover story



Nose cones for Titan and Minuteman are being tested under simulated re-entry conditions with a plasma generator at Avco's new research center in Wilmington, Mass. Temperatures of up to 20,000 deg F have been obtained with the new lab tool.

The generator heats gases by passing them through an electric arc. Gas is injected tangentially into the arc chamber, flows through the area occupied by the arc discharge, of which it momentarily becomes a part, and then through the throat of the anode into a plenum chamber. There different portions of the gas are mixed to produce more nearly uniform plasma temperature and velocity at the exit nozzle.

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Now the Navy has a carrier-worthy jet trainer

For the first time, the Navy can teach its flying cadets to make carrier landings and takeoffs in a basic jet trainer.

The T2J Buckeye trainer has successfully passed the stiff Navy qualification requirements for carrier aircraft. Trials covered a wide range of tests—from shipboard handling...to catapult launching...to touchand-go and arrested landings.

It now joins the Naval Air Basic Training Command in Pensacola to train future Navy and Marine pilots.

The all-purpose T2J gives the Navy a new dimension in basic training. Now the cadet can train in a jet airplane from primary through basic, including instrument flying, armament handling and tactics, combat maneuvers, and carrier training.

The Columbus Division of North American Aviation designed and is producing the Buckeye. It has a stall speed of under 85 mph, yet can fly at 500 mph. It features North American's new deck-level ejection system—equally effective on the ground or in the air...at any speed. Engine and internal equipment compartments are all waist-high for quick, efficient maintenance.

This jet-age addition to the fleet means a broader, more efficient training program for the Navy's jet cadets ... and better-trained pilots to fly the Navy's advanced supersonic weapon systems.

THE COLUMBUS DIVISION OF NORTH AMERICAN AVIATION, INC.

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volume 32, number 2

Technica.	l Ma	nage	ment
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EDITORIAL: The Moment of Truth	MANAGEMENT INTELLIGENCE
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Features

The editorial content of Space/Aeronautics is regularly examined for readability by Robert Gunning Assoc., counselors in clear writing. These consultants meet periodically with the editors and discuss comparative readability ratings.





Avco and a Modern Minuteman—Recent work at Avco led to a solution of the missile reentry problem, and to production of the nose cone for the Air Force <u>Titan ICBM</u>. Now the Air Force announces a development program for <u>Minuteman</u>, a solid fuel missile that will be capable of instantaneous firing with no preparatory fueling delays. Its nose cone, too, will come from Avco's Research and Advanced Development and Lycoming Divisions . . . implementing this modern <u>Minuteman's vigilant defense of our shores</u>.



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in this issue

Here's a quick rundown of the technical information offered in the articles in this issue. You can also use these article abstracts to build up your own permanent record for reference in the future—just clip them, paste them up on standard three-by-five cards, and file them.

Space/Aero Engineering Propulsion, Structures Astia code: 2-1; 12-1; 27-3 Your code:

Space/Aero Engineering Accessory Systems Astia code: 1-2 Your code:

Prime rocketry headache: clean stage separation

Review of basic design problems of stage separation for rocket-powered vehicles. Solutions are described for both immediate and delayed separation for both liquid and solid propellant vehicles.

by Kurt R. Stehling, Contributing Technical Editor space/aeronautics 32/2 (Aug. '59)

p. 42

Two-speed-drive simplifies T-38 accessory system (Design Progress)

Detailed design study of automatic-shifting, two-speed accessory drive used in T-38 and N-156F. Designed by Waste King, the system drives an eight alternator (delivering 320-480 cycles over an engine speed range from idle to full) and a six-hp hydraulic pump.

by Irwin Stambler, Associate Editor space/aeronautics 32/2 (Aug. '59)

p. 58

Space/Aero Engineering Testing, Accessory Systems & Components Astia code: 12-2; 30-5 Your code: Space/Aero Engineering

Vibration-proofing for missile electromechanics

Reviews procedures, specs, and results of vibration testing of the stellar-inertial guidance system for the Snark missile. Fixes used to overcome vibration failures are described, as is the use of rigid assembled, cast, and damping structures in designing against vibration.

by R. S. Dillon, Northrop space/aeronautics 32/2 (Aug. '59)

p. 46

Manned space station needs special "ferries and tugs"

Astia code: 2-1 Your code:

Shows detailed preliminary design cutaway of a re-entry vehicle and "astotug." Gives details on structures and subsystems, with emphasis on propulsion systems. Weight breakdowns are given for both vehicles.

by S. B. Kramer & R. A. Byers, Lockheed space/aeronautics 32/2 (Aug. '59)

p. 61

Space/Aero Engineering Accessory Components Astia code: 1-2; 12-1; 26-8 Your code: Space/Aero Engineering Testing Astia code: 30-3 Your code:

Breakthrough needed for extreme environment fluid sealing

Discusses O-ring seal materials and backup rings for 400-600-deg F applications in hydraulic, pneumatic, cryogenic, and proplusion systems. Reviews work being done on metal rings and inorganic materials for up to 1000 deg F.

by A. A. LePera, WADC space/aeronautics 32/2 (Aug. '59)

p. 50

Strain gages for high temperature measurements

Reviews latest developments in high temperature measurement with strain gages. New types of gages are discussed, and best installation methods are explained. Several typical examples of high temperature installations are given.

by Paul Beckman & Herbert Yanowitz, High Temperature Instruments

space/aeronautics 32/2 (Aug. '59)

p. 65

Space/Aero Engineering Structures, Materials, Propulsion

Astia code: 1-3 Your code: Space/Aero Engineering Ground Support

Astia code: 12-3 Your code:

Acoustic fatigue: key element in high Mach design

Discussion of structural fatigue caused by the intense sound pressures generated by the exhaust flow of turbojets. The effects on the design of current jet transports and possible future Mach 3 configurations are explored.

by Gordon L. Getline, Convair-San Diego space/aeronautics 32/2 (Aug. '59)

p. 54

Hydraulics packs power for missile erection

General requirements and methods for mechanically handling large missiles. Specifically deals with these factors as related to hydraulic system design for Polaris test erecter. Shows complete hydraulic schematic, gives details on component design and operation.

by G. Duane Shaw, The Rucker Co. space/aeronautics 32/2 (Aug. '59)

p. 77

To make filing easier, each abstract is coded according to the Astia Distribution Guide. Copies of this guide are available from Armed Services Technical Information Agency, Arlington Hall Sta., Arlington 12, Va. There is also room on the abstracts for you to insert your own key if you use a special coding system.

Space/Aero Engineering Materials

Astia code: 14-6 Your code:

Space/Aero Electronics

Astia code: 12-2 Your code:

New polyurethane laminates show good flexural strengths

Discussion of experimental glass fiber laminates using new polyurethane resins. Details of the method of formulation of resins and laminates and some physical properties of the laminates are given.

by Angela P. Bonanni, Naval Air Materials Center space/aeronautics 32/2 (Aug. '59)

p. 87

Infrared missile homing proves simplest, most accurate

Explanation of the basic principles of infrared guidance of homing-type missiles. Parameters that must be detected by IR sensors are shown as well as tracking loop requirements.

by Wesley J. Haywood, Jr., Raytheon Mfg. space/aeronautics 32/2 (Aug. '59)

p. 131

Space/Aero Engineering Testing, Materials

Astia code: 30-4 Your code:

Space/Aero Electronics

Astia code: 8-1; 19-3 Your code:

Internal insulation cuts hot gas ducting costs

Ducts carrying gas under pressure at above 1000 deg F are shown to be cheaper if internally insulated. Design problems of such insulation are discussed for the case of Insidline, for which application data are given.

by E. R. Thompson, Baldwin-Hill space/aeronautics 32/2 (Aug. '59)

p. 97

Passive height finder promises 3D ATC (Design Digest)

Design analysis of an experimental fixed height finding system working on "receive only" basis. FAA specs are given and overall functional diagram, sketches of towermounted antenna arrays, beam patterns, sector scan coverage, and waveguide antenna-feed directional cou-

by Bernard Kovit, Associate Electronics Editor space/aeronautics 32/2 (Aug. '59)

p. 135

Space/Aero Engineering Production Engineering, Propulsion

Astia code: 26-1; 27-2 Your code:

Space/Aero Electronics

Astia code: 5-2; 30-5 Your code:

Sheet metal rotors cut weight and cost

Description of a method of making brazed sheet metal rotor assemblies for jet engines that can provide marked weight savings. Sketches of how hollow blades are made and assembled to rotor hubs are included.

by Irwin Stambler, Associate Editor space/aeronautics 32/2 (Aug. '59)

p. 109

Normalized Doppler shift curves

Normalized curves for Doppler shift and its time derivative are plotted on rectangular coordinates. Mathematical derivation of the plot is given. Curves are useful for certain missile scoring devices that sense miss distance by detecting the frequency shift of a missileradiated signal.

by Julius J. Hupert, De Paul University space/aeronautics 32/2 (Aug. '59)

p. 139

Space/Aero Electronics

Astia code: 8-2 Your code:

Space/Aero Electronics

Astia code: 2-1; 30-3 Your code:

Cooling systems for high performance electronics

Comprehensive review of cooling systems for high performance aircraft and missiles. Factors involved in cooling electronics, methods, and types of systems are discussed. Cooling of transistorized equipment and advanced cooling techniques are reviewed. Two specific cooling problems and solutions are given.

by Howard Otto, United Aircraft Products space/aeronautics 32/2 (Aug. '59)

p. 126

How far have we come in space instrumentation?

Review of development progress on instrument packages for satellites and space probes. Samples of important data obtained so far (on radiation belts, atmospheric density vs altitude, occurrence of meteorites, etc.) are plotted.

by Ernst Stuhlinger, ABMA space/aeronautics 32/2 (Aug. '59)

p. 147

5 Ways to Save Fastener Weight

New FN Featherweight locknut series combines minimum mass, outstanding performance



SPS FN-12 Series Featherweight Hex Locknut





Up to 72% lighter than commonly used sheet metal or AN Series nuts. Tolerance on squareness of bearing surface to threads is 50% less than required by specification, providing reduction in stress concentration. Vibration resistance exceeds MIL-N-25027 requirements by 50%.

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SPS Bulletin No. 2426



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Material - Austenitic stainless Plating-Silver

SPS Bulletin No. 2521



SPS FN-22 Series Featherweight 12-Point External Wrenching Locknut





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Characteristics

Sizes-#10 through 11/2 Tensile strength—220,000 psi Temperature—550°F max.

Material-Alloy steel Plating-Cadmium

SPS Bulletin No. 2487



SPS FN-920 Series Featherweight 12-Point External Wrenching Locknut





900°F locknut designed for use with high-strength engine bolts having 0.003 in, reduced pitch diameter. Close control of squareness between bearing face and threads makes these the only standard nuts for their temperature meeting squareness requirements of MIL-N-7873

Characteristics

Sizes—#10 through 3/8 Tensile strength—200,000 psi Temperature-900°F max.

Material-AMS 6304 Plating-Nickel-cadmium, Silver SPS Bulletin No. 2504



SPS FN-1216 Series Featherweight 12-Point External Wrenching Locknut





Offers 160,000 psi tensile at room temperature; 140,000 at 1200°F. Reduced stress concentrations achieved by maintaining 0.003 in. bearing face squareness. Simulated service tests document high lock retention during repeated 100 hr. exposure to 1200°F while stressed to 90,000 psi.

Characteristics

Sizes-#10 through 3/8 Tensile strength—160,000 psi Temperature—1200°F max.

Material-SPS-M-118 (A-286) Plating-Silver SPS Bulletin No. 2468

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coming next month

DYNAMICISTS are discovering that for the new regimes into which missiles and space boosters have pushed them they need new tools, too. One of these tools, a method for gust load determination known as "power spectral analysis," will be reviewed next month.

AUTOMATIC FLIGHT down to touchdown is becoming more of a necessity every day. How far we have come in this field will be shown an extensive design survey in the Space/Aero Electronics section.

coming soon

BASE HARDENING and mobility are the two big trends in GSE. What they mean to the designer will be shown in extensive detail as part of an S/A special report on "Ground Support Engineering", which will bring you up to date on what's been happening and what's in the offing in this rapidly expanding field.

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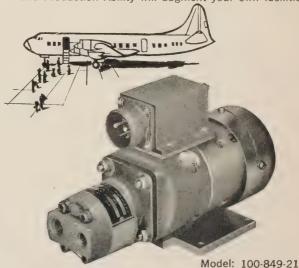
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Are special reports merely a gimmick?

SOME PEOPLE whom we talk to in the industry look upon "special reports" as a publication gimmick for more advertising. While we are not one to turn down pages thrust upon us when we issue special reports, we know that the reports printed by SPACE/AERONAUTICS are not conceived with commercial gain as their sole or even prime motive. We think the history of our special reports will bear out this statement.

We have had quite a number of special reports, beginning in February 1955, when Editor Randy Hawthorne reported on "Small Gas Turbine Progress." So great was the reader response to this initial effort that we made special reports a permanent part of our editorial responsibilities. Our editors try to pick out those developments that merit special editorial emphasis.

For instance, our first special report on "Space Flight" in March 1958 was conceived when "space flight" was a sternly repressed term in Pentagon and Administration quarters. Space/Aeronautics was the first to put this developing industry activity into its technical perspective.

Again, later that same year, Associate Editor Vic DeBiasi bit off a big chunk of work for himself by winning approval for a special report on "Ground Support Equipment." Vic, the project leader for the GSE report, did a superb job in what was then a "neglected" field in the technical press. This report was the first to put the part played by GSE in its technical perspective. As such it was a valuable aid to the industry in general as well as to the people directly concerned in GSE work.

Over the years, our special electronics reports, by Jim Holahan and Bernie Kovit, have given the magazine an international standing in this technological area that is unequaled by other aerospace publications.

Conventional reporting shunned

Are special reports worth all the work, time, and sweat put into them? What is the special aim of such reports?

For one thing, our editors don't take the conventional reporting approach of covering a specific piece of equipment, as do the technical news magazines. We cover a technological area broadly, all in the same time framework, rather than piece by piece over a long period of time. Our editors assume the engineer's mental attitude: first, what do we know—what is the state of the art?

Next, what problems will we face in the near future? How can we apply what we know to solving these problems? Finally, what will we have to do in the way of new developments?

It is this approach which makes our special reports unique. They not only provide the engineer with data he can use in his job, they give the technical manager an insight into new trends that offer fresh opportunities for enterprise.

As might be expected, these reports are not dashed off in the manner of technical news reporting, where the pressure is to be "first". They require a tremendous amount of data and a "feel" for the state of the arts concerned.

The project leader for a special SPACE/AERONAUTICS report coordinates the technical subjects to be covered. In this way, the report achieves a unity of direction and a breadth that supplies the technical perspective. Through it, the technical specialist reader can begin to see the "woods" in which his particular "tree" is located.

Now in the planning and development stage is a "Production & Materials Engineering" report. Here is a field in which—until recently—nothing new or different could be said. Conventional equipment and the practices used for the past 10-15 years were good enough. The reason was simple: Only relatively few materials had been used in vehicle design since the 1930s.

Now, however, a wide range of new materials and structure types is needed. As a result, there virtually is a production "revolution" going on.

a production "revolution" going on.

Associate Editor Irwin Stambler, the project leader, says our report looks like the first comprehensive effort to bring the scope of this production "revolution" to the attention of the engineer and production people. From what Irwin has done in the past, our readers can look forward to another special report of the type that has become a "hallmark" for Space/Aeronautics.

Fine intentions are all very well. But the proof of the pudding is in the eating. Only our readers can attest to that. We welcome your comments and suggestions on special reports, and how they can be made more valuable to you.

William & Mass

HIGH-STRENGTH ALUMINUM CASTINGS



DUCTALUMINUM CASTINGS TO MIL-C-21180A SAVE NORTHROP \$1,500 PER T-38 JET

Using high-strength Ductaluminum castings for three structural canopy supports on the new T-38 supersonic jet trainer saved Northrop \$1,500 per ship. The alternative—a fabricated assembly of hog-outs from forgings and extrusions—would have occupied greater space, weighed nine pounds extra, and cost \$1,500 more for each aircraft.

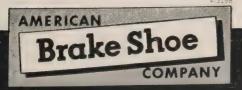
Northrop's example proves that high-strength castings with guaranteed mechanical properties (in the *casting*) can be used in place of forgings, extrusions or weldments for structural parts at considerable savings to the manufacturer. Consider these advantages of castings: lower tooling

cost, intricate design, cast-in lightening holes and bosses, and rigid, one-piece construction. Ductaluminum castings produced to MIL-C-21180A (ASG) specification provide the following guaranteed properties* in highly stressed areas.

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Ductaluminum	356S	42,000	35,000	3.0
Ductaluminum	355	50,000	40,000	3.0

*Higher properties can be guaranteed in castings with favorable design characteristics.

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editorial

The moment of truth

A LL SIGNS POINT to the coming "moment of truth" we shall face over Berlin. The Red picadors—Gromyko, Tsarapkin, Kozlov, and Mikoyan—are lancing the NATO bull in preparation for the Kremlin matador.

Eisenhower's (and the public's) gamble on the "minimum" deterrent policy is not paying off. It is costing us—so far—the Berlin crisis. Moreover, we are moving to the brink of war (at least) over our right to stay in Berlin. Why? Because Khrushchev, for one reason or another, regards our military strength as a diminishing factor.

It isn't enough to convince ourselves that we have the military power to meet the Soviet threats. Khrushchev must be convinced, too. Events speak plainly that his respect for our strength is waning. Indeed, Soviet truculence has grown as our relative strength declined from clear, overwhelming superiority to the present "balance" of forces.

WHAT IS the "minimum" deterrent? Does Mr. Eisenhower know? Does anyone know?

If "minimum" deterrent is what we have today, it has proved extremely dangerous. It has proved dangerous precisely because our idea of a deterrent does not agree with the Red rulers' idea.

Where we are appalled at the prospect of millions of deaths in a nuclear attack, the Soviet rulers are not appalled—if they believe they can survive with enough subjects to rule in the end. The Soviet Union already in its bloody history has exterminated millions of its own people. Red China alone has killed 30 million Chinese peasants, not to speak of thousands of Tibetans, since Mao came to power.

Is it likely such rulers would be deterred from sacrificing millions more of their giant populations, if they were confident of surviving themselves? Can anyone believe they would be more humane in their plans for conquest of other peoples?

What, then, is our definition of "minimum" deterrent military power based upon? Does Mr. Eisenhower have an inside track into what goes on in the minds of Mao and Khrushchev?

THE ADMINISTRATION—for good reasons—has been against spending per se, whether for defense, welfare, or public services. Unfortunately, the fight against non-defense spending hasn't been so sternly pressed as that against the generals and admirals. The more non-defense spending got out of hand, the more constrained the Administration felt it must save where it had more direct control—namely, over defense budgets.

Out of this situation was born the "minimum" deterrent policy. Billions of dollars can be wasted in acquiring and storing unwanted wheat, but only the "minimum" requirements for defense can be met.

How stupid can we get?

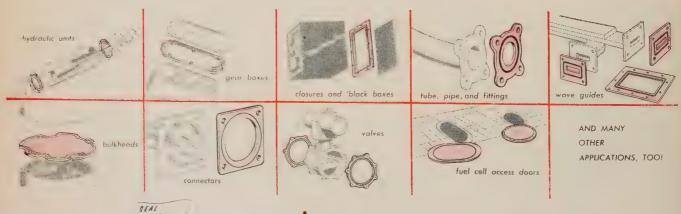
Randolph Hawthorne, Editor



Safe, sure sealing is vital in today's high performance aircraft, missiles and ground support equipment and there is a better way to seal them . . . GASK-O-SEALS.

The Gask-O-Seals shown here are static seals that can actually provide sealing that will exceed hermetic specifications. Yet, they are mechanical, can be removed if necessary, and reused. Controlled confinement of the rubber makes them superior to other seals.

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washington briefing

Aerospace firms looking for foreign licensees

MAJOR U.S. aircraft and missile manufacturers are stepping up their efforts to have their designs produced abroad. Although this is not a totally new situation, there are several novel features about it.

In the first place, both the Defense and State Departments are strongly supporting the idea of having the latest and hottest aircraft in the U.S. arsenal built abroad. Fears that the Russians might be able to learn U.S. secrets more easily if the planes are built in Europe or Japan are forgotten—apparently because there isn't too much the Soviets don't know already.

Another new wrinkle involves the effort to have portions of the U.S. aircraft produced in several countries. Under this setup, there would be only one final assembly line in one country — say, France — but other nations supplying parts would get complete aircraft in direct proportion to the work they did.

American manufacturers would naturally prefer to have countries in Europe and Asia purchase planes or missiles directly from them. However, they are beginning to see that this attitude isn't realistic. The perennial dollar shortage of foreign countries, their lower labor costs, their illogical nationalistic desire to produce their own weapons and maintain their own defense industry all com-

bine to make license production more palatable to them.

Several U.S. aerospace firms have already succeeded in finding foreign licensees. Lockheed's F-104 is to be built in Germany, and Grumman's F11F-1F is slated for production in Japan.

In addition, Lockheed is trying to convince several European countries that its C-130 turboprop cargo plane could be produced economically by a pool of European production talent. Republic is trying the same approach with its Mach 2 F-105D fighter bomber. For its N-156F lightweight fighter Northrop is attempting to line up Fiat of Italy, Sabca of Belgium, and Fokker of Holland. Chance Vought is hopeful that either its Mach 2 Regulus missile or its Mach 2 F8U-3 carrier fighter will be produced in France or elsewhere under license.

The major difference between the Pentagon's current attitude on licensing agreements and its attitude a few years back is that now it's first-line aircraft that are involved. During the Korean War, such aircraft as the North American F-86 and Lockheed T-33 were authorized for production abroad. But by then these aircraft were considered practically second-line.

The fact that the Pentagon is

now willing to release the blueprints for such high performance aircraft and missiles as the Starfighter, Super Tiger, and Regulus 2 can only mean that Navy and Air Force officials concede that the Russians are abreast of us in Mach 2 design. If this were not the case, they would be very reluctant to have vehicles of this type licensed for production abroad.

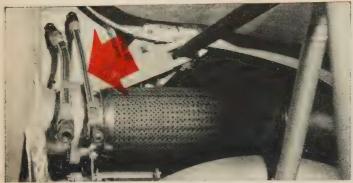
The same applies to such advanced turbojets as the GE J79 and the P&WA J75, both to be produced abroad. Of course, there will be a time lag before any of these aircraft, missiles, and turbojets start rolling out of European factory doors. But the time lag would be short enough to worry Pentagon officials if they were not convinced that the Red aircraft industry is as advanced as ours.

The attempt by Lockheed, Northrop, Republic, and others to have several European countries pool their requirements for a given plane and have components produced in factories of all the countries may prove appealing. It is an expansion of USAF's offshore procurement concept applied to Hawker Hunter contracts five years ago. At that time, Sabca and Fokker split the output of the aircraft's sections, but finished articles were delivered to the Dutch and Belgian air forces from the same assembly line.



problem: supplying 3000 psi. hydraulic power to roll-actuating cylinders on Atlas booster engines.

Convair Solved It with Aeroquip Hose Lines of Teflon



For the sensational Atlas ICBM, Convair-Astronautics engineers employ rocket engines that tilt for directional control of the missile during flight. The hydraulic system needed to tilt the engines required flexible hose lines capable of withstanding 3000 psi. pressure and a wide temperature range.

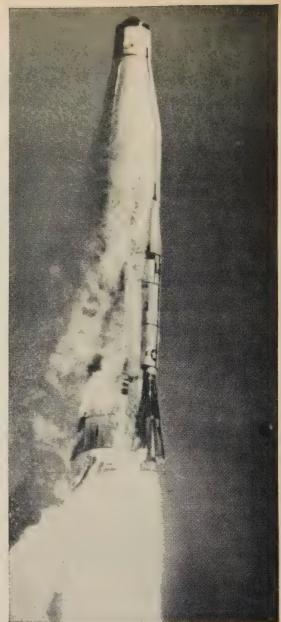
Aeroquip Hose Lines of Teflon were selected because of their known dependability, and because Aeroquip provides a full range of hose types for all pressure and size requirements. In the Atlas installation shown below, the main pressure line (left, above) is Aeroquip 677-8 High Pressure Hose of Teflon. The return line (right) is Aeroquip 666-8 Medium Pressure Hose of Teflon. Both hose lines have patented* **super gem** Fittings.

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Rocket booster engines that tilt provide directional control of the Atlas ICBM during flight.





industry viewpoint

by Robert M. Loebelson, Associate Editor

A better basis for space R&D

THE AMERICAN PEOPLE, their representatives in Congress, and the military services are starting to grasp some of the potential of space activities. Yet much better progress would be made if the U.S. would stop trying to do everything on a crash basis and started building up its knowledge of basic R&D in the space area. This approach, argues General Electric's David Cochran, would result in much better space vehicles in the future.

Cochran, general manager of the Flight Propulsion Laboratory Department at GE's Flight Propulsion Division, in Evendale, Ohio, is convinced that the way to promote space R&D activities is to point up their advantages to the man in the street. Support from Congress will follow, he feels.

"Historically," says Cochran, "R&D support has been tied to the volume of current production in that field. Production orders have included 'surcharges' to cover R&D work in the same general area. But it is almost impossible to transfer the 'surcharges' in a given field to one that is almost completely unrelated."

That, Cochran feels, is the basic trouble with R&D for space activities. As he points out, "the number of space vehicles now being produced is small, and the chances are it will stay small. Eventually, space activities will become an important market. The vehicles will have to travel for long periods and will become larger, to be able to do more complex jobs.

"But space vehicles will remain a small part of the total production picture. What we need is additional R&D funds for basic research on space. In that way, we'll make much better progress than with the impractical 'crash' system."

Cochran maintains that ever since we undertook to probe space, we have been plagued by barriers.

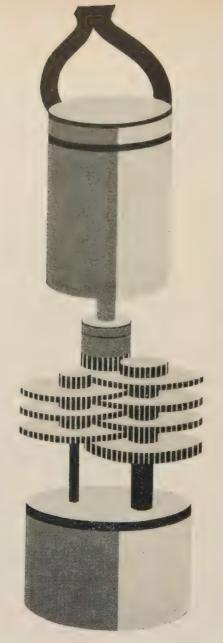
Cochran is convinced that much faster technical progress could be made in the space field if the



DAVID COCHRAN, general manager, Flight Propulsion Laboratory Dept., Flight Propulsion Div., General Electric Co.

government agencies involved would do a better "selling" job on space to the public and if the newer agencies would place greater trust in the industrial firms that form the backbone of space hardware production. "NASA and ARPA," he concedes, "are making every effort to focus public attention on space. But space progress requires a sustained program. And a civil agency like NASA cannot necessarily sustain a team of contractors financially."

Cochran believes the present NASA space research setup has another fault: "When NASA was NACA and didn't do much contracting, the large companies in the industry got along very well with NACA people. Now that NASA has the contracting power, its people seem to be afraid the big companies will try to put something over on them. So they try to get little firms to do a bit of R&D here and a little there. That isn't the way to get things done. NASA must learn to rely on the major aerospace companies for R&D and production, just as the military services do."



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technical management intelligence

DESPITE PRESSURE by influential congressmen and contractors there will be no major speedup in the nuclear-powered aircraft program. All indications are the Administration will continue to spend \$150 million a year on the A-plane program. No fixed date appears to have been set for a first flight.

The Pentagon's Director of Research and Engineering, Dr. Herbert F. York, became the de facto boss of the A-plane project after the death of Deputy Defense Secretary Quarles. York is convinced that, "if anything is done in the way of application of nuclear energy to flight, it will not be done for less than \$10 billion or some multiple thereof."

Work on GE's X-211 nuclear engine is to continue at present pace

ABOUT \$1 BILLION has been spent on the ANP (Aircraft Nuclear Propulsion) project to date, mostly on powerplant research by USAF and AEC. GE's work on the X-211 direct-cycle ANP engine will continue at its present pace, but Convair, which beat out Lockheed in the USAF competition on the ANP airframe, will be held back.

Meanwhile, the Navy's interest in nuclear propulsion continues. Navy officials will soon place contracts with Pratt & Whitney Aircraft (at its Canel plant in Middletown, Conn.) for new development approach. P&WA had been doing work on an ANP engine for USAF, but that project was dropped in mid-'57 because of lacking funds. AEC has been funding P&WA research in the interim.

WILLIAM M. HOLADAY is rapidly becoming one of the biggest mystery men in the Pentagon. At one time he was Defense Secretary Neil H. McElroy's chief adviser on guided missiles and also headed DOD's Ballistic Missile Committee.

Holaday's chairmanship of this committee has been taken over by Dr. Herbert F. York. Holaday also is no longer Director of Guided Missiles-

this post has been abolished.

But Holaday's relatively new post as chairman of the Civilian-Military Liaison Committee is being broadened in power. The committee, made up of four DOD and four NASA representatives, with Holaday as the man with the deciding vote, was set up to settle arguments over the space program.

Originally the Liaison Committee was to take up NASA-DOD problems only if one of the two agencies asked for mediation. Under new rules, the committee will handle all DOD-NASA disagreements as they come up.

Seven Atlas bases announced, four for Titan

NUMBER of announced bases designed to fire ICBMs has reached 11. Seven have been picked for Convair Atlas squadrons, four for the Martin

Atlases will be launched from Francis E. Warren AFB, Wyo.; Vandenberg AFB, Calif.; Schilling and Forbes AFBs in Kansas; Offutt and Lincoln AFBs in Nebraska; and Fairchild AFB, Wash

Titans will be fired from Lowry AFB, Colo.; Ellsworth AFB, S.D.; Mountain Home AFB, Ido.; and Larson AFB, Wash. A fifth Titan base in California will soon be announced.

CURRENT HULLABALLOO over the number of retired officers (with the rank of colonel, Navy captain or higher) working for defense firms will blow over. The hearings by Rep. F. Edward Hebert's House Armed Services Investigating Subcommittee, which are already underway, will cover much of the same ground plowed by the Louisiana Democrat's group in '56-'57.

The House group will find it impossible to prove that retired officers use their friendship with men still in the service to get defense contracts for their employers. Many defense firms with high-ranking officers on their payrolls are starving for contracts.

Retired officers are hired for management talents rather than influence

DEFENSE CONTRACTORS usually hire retired officers for the management abilities they showed while in uniform rather than because of their potential abilities as salesmen.

Hebert has stressed that the hearings will be "fair and impartial". He also admitted that retired generals, admirals, and colonels can be useful to the defense effort after entering civilian life.

Comments by Senate Majority Leader Lyndon B. Johnson (D., Texas) and others that no officers

more on next page



technical management intelligence

have tried to influence them preclude any punitive action against former officers working for defense firms.

WITH SOME MISGIVINGS, Congress has bought the Eisenhower-McElroy "master air defense plan." Both the Douglas-Western Electric Nike-Hercules and the Boeing Bomarc are being cut back, and \$137 million is to be added to the \$200 million originally programed for the Nike-Zeus anti-ICBM program.

The new money for Zeus will be used for additional capacity to produce transistors and resistors. Funds are to go for automation techniques to turn out aluminized plastics in quantity.

"Master" defense plan far from ideal, Congress believes

CONGRESS' IMPRESSION of the "master" plan is that it is "an appreciable step forward" but still far from a suitable long range air defense plan. According to Chairman John Stennis (D., Miss.) of the Senate Armed Services Subcommittee, which handles the program, the issues are not settled. The committee put it this way:

"While the Nike-Zeus system at this stage is not ready for production, every possibility must be explored and the committee, therefore, agrees with the intensification of the program and expresses a strong desire that DOD proceed with all possible haste with the Nike-Zeus and all other anti-missile missile possibilities."

NAVY'S NEW contracting procedure, designed to give contractors better returns and the Navy better aircraft, is being extended. Originally written into a new Grumman contract for the A2F, it now has also been applied to a \$61.8 million award to McDonnell for the F4H. The same "value analysis" amendment will be attached to other Navy contracts for aircraft and missiles.

"Value analysis", according to the Navy, is a new incentive-type agreement under which the contractor shares in the savings resulting from design or production changes that reduce costs. The lowering of costs must not, however, lead to any loss in reliability or performance.

Strategic deterrent to figure in renewed arguments

WATCH FOR more arguments about whether the best defense is a strong offense. With the cost of an effective anti-ICBM due to rise sharply (the Nike-Zeus is down for \$373 million in fiscal '60 alone), proponents of an extensive build-up of strategic weapons are becoming more vocal.

Under the present setup, Defense Secretary McElroy is putting by the greatest part of the dollars and effort in the DOD budget into strategic weapons such as the B-52, B-58, Polaris, Atlas, and Titan. Second priority is going to weapons for limited, or "brush-fire," wars. Ranking behind these two in importance are air defense, missile defense, and anti-submarine warfare

McElroy concedes that the rising cost of defense against enemy bombers and missiles strengthens the arguments of those who want us to build up our strategic power—especially since there is no way of really knowing whether defense weapons are any good until an attack is launched against us. But there is now little doubt that the Chiefs of Staff defensive weapons like Zeus, Hercules, Bomarc, F-108, etc., must be continued.

Renegotiation Act extended for three years with only minor changes

DEFENSE CONTRACTORS will have to live with the renegotiation principle for at least three more years. In the final version, the new Renegotiation Act—which will run until June 30, '62—contains only a minor change from the former law: A five-year carry-forward on losses of renegotiable business is permitted.

Aerospace and other defense companies that opposed renegotiation as a concept as well as the Renegotiation Board's interpretation of the '61 Act still have a longrange hope—both the House and the Senate Armed Services Committees have scheduled full-scale studies of military procurement methods in an effort to find out whether reforms are needed.

USAF EXPECTS to start firing two new types of sounding rockets from NASA's Wallops Island, Va., station in the near future. The project is being handled by ARDC's Special Weapons Center at Kirtland AFB, N.M.

THE Journeyman is scheduled for four firings. It is composed of a Sergeant, two ABL solid rockets and ABL's X-248. It will take a 40-lb. payload 2000 miles up.

more on page 26



Instrument Ball Bearings Help Missiles Along A Bright Path Of Precision!

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Missile guidance system manufacturers require a dependable source for super precise instrument ball bearings. When used in spin axis and gimbal applications, for example, these ball bearings help restrict vitally important drift, through extremely close tolerances and high precision uniformity.

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technical management intelligence

Prime contractor for both sounding rockets is Aerolab Development, of Pasadena, Calif.

CONTINENTAL ARMY COMMAND is analyzing a study by the Army Aviation School. Fort Rucker, Ala., that recommends that the 15 airplane types in the present Army inventory be reduced to six by '70. These six types are designed primarily for operations in a limited war:

- light, unarmed observation vehicles that will replace the Cessna L-19;
- medium observation planes to provide information on enemy targets for field weapons;
 - heavy observation aircraft;
 - VTOLS for general tactical use;
 - VTOL transports;
 - STOL transports.

ARPA plans to broaden its operations, slates materials studies

ROY W. JOHNSON'S Advanced Research Projects Agency is planning to stay in business for years to come. With USAF's Maj. Gen. Don R. Ostrander due to replace Rear Adm. John E. Clark as Johnson's deputy on Oct. 1, the DOD agency has programed a broadening of its operations. One area of expansion that has been approved by Defense Secretary McElroy and R&E Director York covers basic studies leading to new materials. All of the work (\$15 million for fiscal '60 alone) will be done at colleges and universities.

ARPA is also looking into missile defense 20 years from now. More than 50 programs have already been studied to find out whether they will be "technically, operationally and economically feasible." RCA, for instance, has a \$600,000 feasibility study contract on the tracking and interception of satellities. The RCA data is expected to be embodied in a system scheduled to be operational by '65-'70.

PRODUCTION of the Army's Hawk surface-to-air missile in Europe is a certainty. Operating under a special NATO group in Paris headed by Maj. Gen. W. J. Reijnierse of the Dutch air force, the Hawk production team will receive technical assistance from Raytheon, Northrop, and Aerojet-General.

Five European manufacturers have created

Setel (Société Europiénne de Teleguidage) to build the Hawk and other weapons for NATO nations. Setel includes Philips of Holland, Telefunken of Germany, Constructions Electriques Charleroi of Belgium, Finmeccanica of Italy, and Thomson-Houston of France. Final assembly of the Hawk will be Thomson-Houston's responsibility. Fokker will probably take part in the Hawk program, too.

Present program calls for Setel to build about

\$400 million worth of Hawks.

200 Lockheed F-104Gs to be built in Canada as CF-100 replacements

CANADA picked the Lockheed F-104G over the Grumman F11F-1F Super Tiger and the Republic F-105 as the replacement for eight squadrons of CF-100s. The nine CF-100 squadrons allotted to North American air Defense are not affected.

About 200 planes are involved. Orenda will probably be licensed to build the GE J79, and Canadair will probably win out over Avro in the Canadian competition to build the airframe.

DOUGLAS DECIDED to go ahead with the DC-9 jet transport, with deliveries possible in '63. The short-to-medium range jet will use four P&WA JTF10A-1 turbofan engines. It will not be released for production until Douglas has a "reasonable number" of orders.

Bell, Kaman, Vertol studying nuclear helicopter

FEASIBILITY STUDIES on a giant nuclear-powered helicopter are being run for ARDC by Bell, Kaman and Vertol. USAF has no funds for such a vehicle at present but is interested in future possibilities. The A-copter may be as much as 300 ft long, weigh 500,000 lb and cruise at 200 mph.

FOLLOW-ON contract totaling \$25.6 million was placed by the Navy for the F8U-2N Mach 2 limited all-weather fighter. Chance Vought will start deliveries to the fleet in '60.

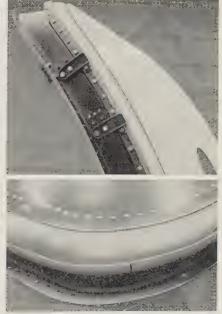
ARMY PLACED a \$19 million letter contract with Vertol for YHC-1B Chinook helicopters. Vertol will roll out the first Chinook, powered by two Lycoming 1940-hp YT-55 turboshafts, in November '60.



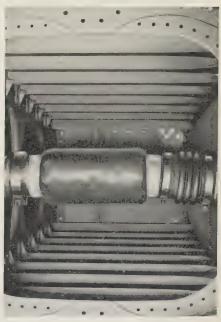
DC-8 uses newest G-E silicone rubbers



RTV compound used for caulking and sealing. RTV (room temperature vulcanizing) silicone rubber cures without the application of heat in any time you select up to 48 hours. It won't shrink (no solvents); forms no voids. RTV has excellent bond strength—plus resistance to high temperatures (above 600°F), moisture, weathering, ozone, aircraft fuels and solvents. Tough, elastic, good electrical properties.



SE-555 silicone rubber gaskets on door (above) and hatch. SE-555 has substantially double the strength of ordinary silicone rubbers. It combines maximum resistance to weather and temperature extremes (-150°F to 500°F) with the high tensile and tear strength previously found only in organic rubber. SE-555 meets AMS 3345 standards and can be fabricated in any color, including white.



Hot air duct of glass-cloth-reinforced Class 700 silicone rubber with flexible connectors of same material. (Ends sealed with General Electric RTV.) Ducts of G-E Class 700 silicone rubber have a service range from -120° F to 600° F and in other applications carry air up to 700° F. They resist common aircraft fuels and lubricants, have low compression set, and will not "cold flow" away from clamps.

For application data on G-E silicone rubbers, write General Electric Company, Silicone Products Dept., Section 18R7 Waterford, N. Y.



Silicone Products Dept.

Waterford, N. Y.

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NEW DIMENSIONS IN

reliability





space/aero engineering intelligence

LITTLE JOE vehicle for early stages of Mercury manned satellite program consists of launcher, and booster vehicles and a full-size capsule, NASA disclosed. Built by NAA's Missile Div., Downey, Calif., the craft has a maximum diameter of 6½ ft. The booster-capsule combination is 44½ ft long.

The booster has four Castor and four Recruit solid propellant engines, with a total thrust of about 372,000 lb. Recruits, made by Thiokol, were used as second and third stages on the X-17 and on Project Farside.

Four Recruits add 132,000 lb thrust to two Castors' initial 120,000 lb

AT LAUNCH, two Castors are fired to give 120,000 lb thrust. Four Recruits are ignited half a second later to add 132,000 lb thrust. After burnout of these rockets, the final two Castors fire. The Castor is basically an Army Sergeant engineer with canted nozzles instead of straight ones. Its solid propellant is made by Thiokol.

The launcher for Little Joe is supplied by NAA.

EINSTEIN'S THEORY of relativity will be tested by special "clocks" installed in satellites. NASA has awarded contracts for two different types (1) an ammonia maser design to be built by Hughes Aircraft's Atomic Physics Dept. and (2) an optically excited gas cell using rubidium atoms, to be built by NBS. The clocks use a vibrating atom or molecule to produce a constant ticking. The vibrations are electronically counted. Ammonia provides about 24,000 million ticks per second, cesium 9200 million, and rubidium 6700 million. Counting is done by a servomechanism that synchronizes a slow, or low frequency, clock with the fast, high frequency atomic clock by means of an electronic frequency divider circuit.

Readings of clock traveling at 18,000 mph in space to be evaluated

IN TESTS, Dr. Harold Lyons, of Hughes, states, the clock in the satellite (traveling at about 18,000 mph) will periodically transmit its time reading by radio to a ground station, where the value will be compared with that of a similar earthbound clock. According to the theory

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of general relativity, the satellite clock should run slow compared with the ground clock for orbits under 2000 miles and fast for orbits over 2000 miles—because the effects of motion predominate below this altitude and those of gravity above it.

DC-9 to replace DC-6B, will carry 68 in first class

DOUGLAS DC-9 performance characteristics were revealed. The craft will be 103 ft long, with a height over tail of 34 ft and a wing span of 94 ft. (The DC-6B, which the new jet is to replace, has a 117-ft span, 106-ft length, 29-ft height, and 107,000-lb gross weight.

The DC-9 will carry 68 first-class passengers and have a maximum takeoff weight of 120,000 lb. Power plant is the P&WA JTF 10A-1 turbofan, which develops 8250 lb thrust at sea level on a 90-deg F day.

AT MAXIMUM takeoff weight, the DC-9 will carry its first-class payload 2500 miles at point-to-point speeds of 520 mph, Douglas states. At shorter ranges, the cruise speed will be over 580 mph. Normal cruise altitude will be up to 35,000 ft.

The wing area is 1285 sq ft. The cargo area is 609 cu ft, enough for 9135 lb of freight. The free-and-aft wheel base is 42 ft, the main wheel tread 19 ft. Payload is 20,355 lb; zero fuel weight, 87,000 lb; structural design landing weight, 98,000 lb. Interior measurements of the cabin are 71-ft length, 124-in, width, and 81-in, height.

At maximum takeoff weight, FAA takeoff length is said to be 5950 ft on a standard day and 6840 ft on a 41-deg F day. FAA landing length at 2590 miles range and maximum takeoff weight is 4800 ft.

The coach configuration can take 92 passengers.

Soldering method does away with warping, crimping, twisting

NEW SOLDERING method developed by Cubic, of San Diego, Calif., was approved by USAF in Mil-E 5158B. It eliminates the warping, twisting, or crimping of wire leads and component pigtails to terminals or points before applying the solder, Cubic states. Instead it uses setups in which the wires are slightly bent or placed in a hole or slot before soldering.

more on next page



space/aero engineering intelligence

MIXED POWERPLANTS for Mach 3-5 transports are already a thoroughly flight-tested reality, J. M. Cummings, of Rocketdyne, told the recent ASME meeting in St. Louis, Mo. He noted that Rocketdyne has completed a four-year program in which small, 5400-lb thrust liquid propellant rocket engines, were flown repeatedly in a Navy FJ-4 fighter.

Four different models of this engine have been developed, ranging in length from 31.5 to 56.7 in. with nozzle diameters from 15.4 to 19.5 in. The first models weren't throttleable, but later versions have thrust controllers, which are electric devices to refer the operating pressure of the thrust chamber to the setting of the pilot's control quadrant. With this reference, the controller regulates the oxidizer flow.

THE OXIDIZER is hydrogen peroxide. Multiorifice-type injectors are used. The turbopump assembly includes fuel and oxidizer pumps and a turbine to drive them. The fuel pump delivers 30 gpm against 1300 ft of head. The thrust chamber is of stainless-steel, double-wall construction and has regenerative cooling. The oxidizer-fuel ratio is 7:1.

For supersonic transports, Cummings suggests, economical takeoff, climb and acceleration could be provided by large liquid rockets combined with turbojets. One possibility would be to use an S-3 rocket with 150,000 lb thrust together with two turbojets to give 154,600 lb overall thrust during takeoff and climb.

Dyna-Soar booster has to be Atlas, Titan or Saturn under recent Defense Dept. ruling

THE CRUCIAL DYNA-SOAR problem now is the selection of a booster. Reportedly DOD has ruled out any new booster development. This means an Atlas, a Titan, or a Saturn booster must be used.

The present Titan has the wrong configuration for the Dyna-Soar design proposed by the Martin-Bell team. A bigger Titan system has been suggested, but the many mods it would require almost put it into the class of a new booster development.

A GIANT SOLID booster of over 10 million lb thrust that Boeing proposed for Dyna-Soar

was shelved even before the DOD ruling. Estimates are that it would have cost over \$200,000,000 to develop. Boeing is now talking of an advanced version of Atlas.

Saturn is scheduled to be operational in time for use on Dyna-Soar

ARMY'S SATURN looks like the best technical answer for Dyna-Soar. It is being developed by Huntsville. Static tests are scheduled for December and it could be operational early in '61—in time for both the Dyna-Soar A 6000-mile-range glider and the Dyna-Soar B orbital bomber.

P&WA'S 15,000-LB THRUST hydrogen-oxygen rocket engine, being developed for Centaur, was test-fired. Most of the fuel system and thrust chamber problems reportedly have been licked. The liquid hydrogen pump for the fuel system is considered operational.

The big development problem, P&WA has been afraid, would be lubrication. But the liquid hydrogen proved a good enough lubricant to make all external lubrication for the propellant pump superfluous.

CENTAUR'S THIRD STAGE, being developed by Jet Propulsion Lab, will weigh about 6000 lb and burn a storable combination of N_2O_4 and hydrazine. It will make it possible to launch a 3000-lb "stationary" satellite into a 24-hr orbit.

The Centaur combination is also designed for use with interplanetary probes. Its second and third stages can be restarted in space.

Second stage of Vega to use improved first stage of Vanguard

VEGA may actually be completed a year earlier than the Centaur system, for which it is the backup. It uses Centaur's Atles booster but the second-stage engine is an improved version of Vanguard's first stage. A JPL third stage may also be used. However, the three-stage Vega will have only one-fourth the payload capability of the Centaur.

more on page 32



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Experience in building things from dreams has always been part of Ex-Cell-O. Precision in design, precision in manufacture for forty years has been the Ex-Cell-O tradition. Now as we near the conquest of space, even more important becomes speed of translation from dream to reality. And for this Ex-Cell-O's history and facilities are yours for the asking.

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HIGH TEMPERATURE lubricants contracts were awarded to Dow Chemical to produce polyphenyl ethers for WADC evaluation as radiation-resistant types. An extensive operational evaluation program has been set up to test the ethers' performance as oils, hydraulic fluids, and greases for developmental jet engines and other hardware.

Five thousand pounds of bis (phenoxyphenyl) ether and bis (phenoxyphenoxy) benzene will be produced. In an oxidizing environment such as air, the two ethers will have useful temperature ranges of 20-600 and 40-600 deg F, respectively. In a non-oxidizing atmosphere such as nitrogen, both fluids are reported to have a useful temperature range extending up to 900 deg F.

No precision components in Italian C-7 infrared missile's electromechanical system

ITALIAN INFRARED C-7 air-to-air missile has a range of 3-6 miles and an operating ceiling of about 33,000 ft. Unique design feature is the reported elimination of precise electromechanical components such as gyros from the guidance system to keep costs and maintenance down. The C-7 is about 6½ ft long and has a wing span of 25 in.

PYROCERAM MIRRORS developed by Corning Glass Works use sandwich construction. Two thin plates of Pyroceram are held apart by short lengths of Pyroceram tubing. The assembly is then ground and polished to high optical accuracy by standard techniques.

The Pyroceram composition used in these mirrors has an expansion coefficient of essentially zero between 100 and 150 deg F, says Corning. The mirror curvature remains fixed between these limits.

Forging with special lubes and argon heating atmosphere

NEW FORGING technique for jet turbine blades has been developed by Thompson Ramo Wooldridge's Tapco Group. It is being used to produce columbium blades for a high performance engine now under development.

Special lubricants and an argon atmosphere for heating processes are needed to precisionforge the air foil shapes. Dimensional accuracy of the process is so good, says Tapco, that only polishing operations are needed to finish the forged air foils.

ASTOR SUBMARINE weapons system, being developed by Westinghouse at Baltimore for BuOrd, will be used against both underwater and surface targets. Astor itself is an electrically driven high speed torpedo-missile. It is about 20 ft long and weighs over a ton. Its range has not been disclosed.

"Lightest, most effective" shield against neutron radiation

RUBBER-BASED NEUTRON shielding material developed by Goodyear Tire & Rubber can be poured or cast into shape. Scientists at Goodyear say the new shielding is believed to be the lightest and most effective material developed so far to withstand neutron radiation.

Although the new shielding material has a high hydrogen content, it can withstand temperatures from 160 to 200 deg F, says Goodyear. The hydrogen is used to slow down the neutrons. A powdered metallic boron captures them. Once cast, the material cures at very low or ambient temperatures.

RECENT VANGUARD failure was attributed to a faulty second-stage pressure valve. A regulator designed to control the helium flow for the second stage propellant pressurization system did not operate on radio command.

Without sufficient pressure on the propellants' the second-stage engine ran rough. Pressure buildup within the helium reservoir then ruptured the helium tank about 40 seconds after ignition.

Forty per cent of Titan structure is made up of magnesium thorium

MAGNESIUM THORIUM alloys are used extensively in the Titan. About 40 per cent of the Titan skin structure is made up of magnesium-thorium sheet and extrusions, according to Martin-Denver. Total weight of the ICBM is about 2000 lb.

HK31A sheet is used in the transitional sections of the structure—between the first-stage fuels and oxidizer tanks, between the first and

more on page 34



or shape
a missile

of pressure—so delicately controlled that it can be made to crack the shell of an egg.

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second stages, between the second stage and the nose cone. HM31A extrusions are used for the external conduits between the fuel and oxidizer tanks in both stages and for internal parts such as stringers, longerons, and hinges.

Prefab Jupiter shelter to be assembled during standby

JUPITER'S base shelter, being produced by Aeronca, Middletown, Ohio, is a prefabricated structure to be erected around the missile and launcher assembly while the missile is in the vertical standby position. It will help in the temperature and humidity control of the missile tail assembly.

BOUNDARY LAYER CONTROL for blimps is expected to increase their speed by as much as 40 per cent. Experiments are now being made at the Naval Air Station in Lakehurst, N.J. Best place for the suction holes is said to be in projecting fins and along the intersection of the fins and the bag structure.

The same BLC technique may be applied to submarines.

Railborne launcher for ICBMs would be disguised as passenger train

RAILROAD LAUNCHER train for ICBMs is being worked on by Bethlehem Steel and Hardeman, an engineering and construction company. The train would consist of a number of cars disguised as freight or passenger types and of an engine. Missiles would be carried in cars specially designed to protect them against shock and excessive temperature changes.

A self-contained erector would raise the missile into position on a special launching car equipped with flame shields and stabilizers. Tactical firing data would be obtained from another car on the basis of precharted calculations.

FIREFLY missile-copter proposed by Solar is launched like a missile and hovers like a copter. The remote-controlled fire-fighting vehicle can be precisely directed to any spot within five miles in 40 seconds or less.

Three rotor blades are locked back to serve as tail surfaces during the rocket-powered trajectory. A solid propellant rocket slung under

the fuselage provides the boost power. At the end of powered flight and glide, the rotors are unlocked and energized as small rocket motors fire in each rotor blade tip.

FIREFLY is about 16 ft long, not counting rotors and the spray nozzle in the nose. The wing span is about the same. The vehicle weighs about 5000 lb, including the extinguisher payload.

According to Solar, the Firefly could be built from modified existing equipment.

Successful transition flight made by Doak 16 VTOL

ARMY'S DOAK 16, or VZ-4DA, a ducted-fan research plane, made successful in-flight transitions from vertical to horizontal and back. Power-plant is an 840-hp Lycoming T53.

PIASECKI'S LATEST aerial jeep for the Army, the VZ-8P, has made vertical take-offs, landings, hoverings, and other mid-air maneuvers. Engine is a 425-hp Continental Artouste 11B.

HILLER X-18, large VTOL research plane, will begin flight tests at Edwards AFB, Calif., later this summer.

BREGUET 940 INTEGRAL, four-engine, seventon STOL transport has completed successfully first flights at Toulouse, France. Four 400-hp Turbomeca Turmo II shaft turbines power the plane, Breguet and Piasecki are cooperating on a larger, 20-ton version.

Honest John, Nike-Asp and Lance boost six-stage rockets in Wallops Island tests

NASA and ARPA are studying re-entry problems by firing six-stage rockets at Wallops Island, Va. The vehicles have Honest John, Nike-Asp, and Lance boosters as the first three stages. The other stages (in a single airframe) use the Thiokol T-40 and T-55 rocket motors and a special five-in-a-diameter spherical motor designed by NASA-Langley.

ATLAS-HUSTLER, with a Convair Atlas first stage and a Bell rocket engine in the second stage will be used to boost Midas, Sentry, and Transit satellites into orbit.



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For specific dimensional, design and test data on ESNA's new, lightweight, 220,000 psi nut—Type LH3393, write to Dept. S23-850 Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey.



*U.S. Patent No. 2,588,372

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calendar

August 4-5—Second Annual Western Regional Meeting, Amer. Astronautical Society, Ambassador Hotel, Los Angeles, Calif.

August 5-7—William Frederick Durand Centennial Conf. on the Problems of Hypersonic and Space Flight, Stanford Univ., Stanford, Calif.

August 9-12—Third National Heat Transfer Conf. & Exhibit, Amer. Society of Mechanical Engineers, Amer. Institute of Chemical Engineers, Univ. of Conn., Storrs, Conn.

August 10-13—National West Coast Meeting, Society of Automotive Engineers, Hotel Georgia, Vancouver, B. C.

August 11-13—Wright Air Development Center Symposium on Aircraft Structural Fatigue Problems, (Confidential clearance required; must be filed with the Symposium Arrangements Committee, WCO, WADC, Wright-Patterson AFB, Ohio) Dayton Biltmore Hotel, Dayton, Ohio.

August 17—First National Ultrasonics Symposium, Institute of Radio Engineers Professional Group on Ultrasonics Engineering, Stanford Univ., Stanford, Calif.

August 18-21—Western Electronic Show & Convention, IRE, Cow Palace, San Francisco, Calif.

August 24-26—Institute of the Aeronautical Sciences' National Specialists Meeting, Symposium on Anti-Submarine Warfare (classified), San Diego, Calif.

August 27-28—International Commonwealth Spaceflight Symposium, Church House, Westminster, London, Eng.

August 31-September 2 — Annual Army-Navy Instrumentation Program (ANIP) Symposium & Industry Briefing, Statler Hilton Hotel, Dallas, Texas.

September 1-2—Conf. on Physical Chemistry in Aerodynamic & Space Flight, Air Force Office of Scientific Research & General Electric Co.'s Missile & Space Vehicle Dept., Univ. of Pennsylvania, Phila., Pa.

September 2-4—1959 Cryogenic Engineering Conf., Univ. of Calif., Berkeley, Calif.

September 3-6—National Convention & Aerospace Panorama, Air Force Assn., Exhibition Hall, Miami Beach, Florida.

September 6-16—Fifth Annual Production Engineering Show, Navy Pier, Chicago, III.

September 7-11—National Technical Conf., Illuminating Engineering Society, Fairmont & Mark Hopkins Hotels, San Francisco, Calif.

September 7-13 — 1959 Farnborough Flying Display & Exhibition, Society of British Aircraft Constructors, Farnborough, England.

September 9-11—Sixth Midwestern Conf. on Fluid & Solid Mechanics, AFOSR/Directorate of Aeronautical Sciences, Office of Naval Research; National Science Foundation, Univ. of Texas, Austin, Texas.

September 16-17—Western Regional Meeting on Frontiers of Science & Engineering, IAS, Los Angeles, Calif.

September 17-18 — Engineering Management Conf., ASME, Statler-Hilton Hotel, Los Angeles, Calif.

September 18-19—Third Biennial Technical Symposium, "Antennas and Propagation," Cedar Rapids Section IRE, Sheraton Montrose Hotel, Cedar Rapids, Iowa.

September 20-25 — 14th Annual Conf. & Exhibit, Instrument Society of Amer., Chicago Amphitheater, Chicago. III.



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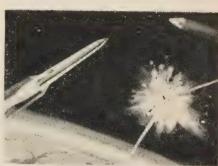
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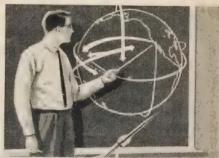
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LITARY AND INDUSTRY IN SCIENCE AND TECHNOLOGY

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Upgrading the engineer

into technical management

More and more the aerospace industry is recognizing that it needs technical people in management. What's much less obvious is, Where do you get these people? Here is a report on the approaches worked up by several leading aerospace companies.

by Robert M. Loebelson, Associate Editor

WHY DO SO MANY engineers in the aerospace industry want to become a part of technical management? Money is obviously an important consideration. But studies and interviews by SPACE/AERONAUTICS show dollars are not the dominant factor.

The vice president of administration at Space Technology Labs, for example, considers dollars the least important of four basic motives. Says STL's Frederick W. Hesse:

"Engineers generally seek to move up to the management level because of the depth of the technical challenge, the opportunity to progress in responsibility, and the desire to obtain professional recognition. The quest for the dollar ranks behind these others."

Top management is encouraging the technical man to try to widen his horizon and become a member of the management organization. The assistant manager of industrial relations for Garrett's AiResearch Manufacturing Division, John Muchmore, explains it this way:

"During the depression, comptrollers and other fiscal experts were the most important members of the management team. When World War II broke out, manufacturing experts became dominant. With the change in emphasis and the importance of scientific progress, the greatest emphasis now is on finding managers who are well qualified technically."

Yet top management is convinced that relatively few engineers are really qualified to make the move upward. "Sparky" Seybold, Convair's vice president of engineering, for example, declared flatly that "in every group of 100 engineers, there are only one or two potential project engineers."

Every company in the aerospace industry is confronted with the problem of a shortage of technical managers. None, of course, can simply duplicate USAF's approach. The Air Force and the other services have the same sort of technical management requirement as do aerospace firms. When they found that they did not have enough officers to handle their technical-administrative job, they lined up management organizations—for instance, Space Technology Labs for missiles and Mitre for air defense problems.

Insiders favored by companies

Industry firms have adopted several methods of overcoming the shortage of technical management talent. An obvious technique is recruiting outside the company.

But as Warren Matthews, vice president of engineering at Hughes Aircraft, points out, "the feeling is growing that it's only the technical man who can have bounced around from company to company before he comes on your payroll." The same thing is not true of

administrators. When a company seeks a man for a technical management position, it usually looks for somebody with a record of stability.

Despite their belief that only a few engineers have the capacity to develop into members of technical management and are therefore rare finds, aerospace companies are dubious about recruiting from the outside. It's simply one of the facts of life in the industry that personnel of the caliber who are recruited from other firms usually have many shortcomings. The upshot is a continuing effort to develop and promote insiders.

The program at Aerojet-General is fairly typical. A. J. Wilson, manager of personnel development, explains the company is using a multi-point program to help potential technical managers. Among its projects are:

- an educational refund plan, under which employes may get a two-thirds tuition refund for appropriate courses taken at accredited schools on their own time;
- after-hours courses at Aerojet's Azusa plant that, at college level, cover such subjects as rocket engine theory, design and testing, introduction to transistor electronics, "creativity" for engineers and technicians, speed reading, and speech techniques;
- in-service training, which involves a 12-session course in supervision practices on company time by first-level supervisors and a 10-session course on management techniques for higher-ranking supervisors (other courses in the works cover technical report writing, conference techniques, engineer indoctrination, and work simplification and cost control, to be taught in some cases half on company and half on personal time);
- a company-subsidized graduate work program at UCLA's Chaffey College, Ontario, Calif., that leads to a master's degree in mathematics or general engineering;
- a work-study program, under which the company grants leaves of absence or half-days.

Convair offers night courses

At Convair-San Diego, the approach is similar. In addition to courses for engineers at the plant (patterned along lines recommended by the American Management Association), Convair has worked with California Western College to set up night management courses and with San Diego State College to provide advanced technical courses. About 90 per cent of the enrollment at the two schools' special courses is made up of aerospace industry employes.

Robert Biron, Convair's vice president for administration and industrial relations, thinks he has detected a common denominator in men who want to become part of technical management. "About six years ago," he says, "we started an executive development program. All of the projects designed to create managers were provided on company time. After a year, the program started breaking down. We have now turned the program around so that ambitious men must demonstrate their interest in moving up to the management level

by investing their own time as well as the company's."

Lockheed's James Lydon, director of industrial relations, tends to agree. Says Lydon, "The engineer who truly wants management responsibilities is rare. But for those who do and who demonstrate their interest, Lockheed's management development program is working out well."

Lydon reports Lockheed's approach involves specific and difficult assignments for engineers on the way up, job rotation to provide all sorts of management experience, and outside training courses tailored to individual needs.

Douglas provides scholarships

Douglas, on the other hand, has no management development program as such. According to John Buckwalter, assistant to Douglas senior vice president Arthur E. Raymond, the Santa Monica firm selects engineers for promotion in three ways:

- In a semi-annual review of the engineer's performance, he and his supervisor discuss strong and weak points. These conversations may lead to recommendations for university courses or assignment to other job areas. As time goes on, these reviews may take place more frequently. Copies of the supervisors' work performance review are sent to the Douglas Engineering personnel office.
- Salaries are reviewed by a special board, that has no direct connection with the supervisor's work-performance review. The board is normally made up of the engineering personnel manager, the administrative and design engineers, the engineer's immediate supervisor, and a representative of the general office.
- A Senior Review Board fills supervisory positions. This board usually includes the chief or assistant chief engineer, the administrative and design engineer, and a representative of the general office. Buckwalter emphasizes that personal observation by his superiors is what basically determines whether an engineer moves into technical management.

Although it has no specific executive development program, Douglas nevertheless uses several approaches to make engineers more valuable to the company. Included are scholarships (full-time for a maximum of \$1500 a year or night courses for up to \$50 a course) and in-plant courses.

In the latter category is a five-day supervisory course given to all engineering supervisory personnel. The course was taken by about 675 Douglas employes last year and was given by CalTech industrial relations professors. Douglas is planning follow-on refresher courses.

Another course provided in the plant on company time is designed for group engineers (who direct 2-15 other engineers but do not have the right to hire and fire). The sessions, taught by Douglas supervisors and by UCLA, University of California, and CalTech professors, cover such subjects as communications, work assignments, the Douglas engineering system, human relations, and conferences and meetings.—End

Prime missile headache:

clean stage separation

An amazing number of missile and spacecraft aborts can be traced to the same cause—failure of the stage separation system. Here is a report on what makes the separation problem so tough to lick.

by Kurt R. Stehling, Contributing Technical Editor

AT THE PRESENT state of the propulsion art, we can't get very far with a single rocket. For the foreseeable future, we are stuck with multi-stage designs for the larger missiles and all spacecraft.

In virtually all multi-stage vehicles, only the last, topmost stage makes the entire trip. The lower stages are merely "boosters" and are supposed to drop off whenever they've done their propulsive job. To the designer, multi-stage vehicles therefore mean that he has to worry about stage separation—and experience shows there's plenty to worry about.

FIGURE 1: The propellant tank dome of the lower stage must be protected against a blast-through when the engine of the separating upper stage is ignited. The sealing plug in the nozzle throat of the upper-stage engine makes ignition at high altitude possible.

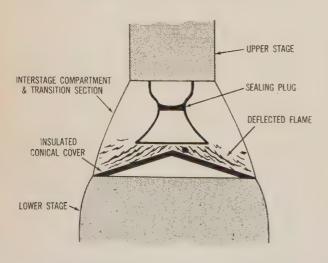
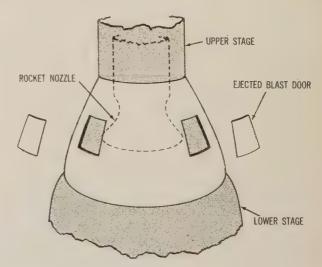


FIGURE 2: Blast doors often are used in the transition section when an upper stage must be fired immediately upon shutdown of the lower stage. As the flame of the upper-stage engine sprays out of the holes left by the blast doors, harmful pressure build-up is avoided.



There are several ground rules of stage separation that the designer cannot get around:

- If each stage above the first is to ignite upon shutdown of the previous stage, a rather intricate sequence of thrust decay in the lower stage and thrust rise in the upper is needed. Furthermore, explosive or mechanical devices must be provided to cause the actual physical pulling apart of the stages.
- If the thrust rise of the upper, or escaping, stage is to be delayed beyond the moment of separation, there must be some elaborate thrust control. In addition, the lower, or "mother," stage must somehow be gotten out of the way to make sure that it will not interfere with the upper stage. (In one Explorer shot, a lower stage did not get out of the way, and that was that.)
- Since upper stages usually must ignite in a vacuum, special precautions are needed to insure smooth combustion. The great danger is that the blast from the igniting upper-stage engine might burn into the pressurized propellant tanks of the lower stage, which then can explode and perturb the upper stage, to put it mildly (Fig. 1).

In their details, separation designs naturally are tailored to specific applications. However, they all share some common features.

If each stage of a vehicle must fire immediately upon shutdown of the previous stage, there must be a blast compartment with adequate venting for the exhaust flame (Fig. 2). Otherwise a pressure build-up might occur that can have destructive effects on the firing stage or quench the fire in the stage's thrust chamber.

In relatively simple rocket vehicles like Vanguard, it's fairly common to provide two or four blast doors

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in the transition section between the first and second stages. When in the course of the second-stage ignition sequence the engine is fired, an electric signal also fires explosive bolts that loosen or flip out vent doors. When the exhaust flame has built up, a second signal fires explosive bolts around the periphery of the transition section, leaving a sheared ring of metal (Fig. 3). The second stage then is free to fly on into space.

Designers often disagree in their preferences among explosive bolts, primacord, and mechanical latches for separation functions (Fig. 5). Many static tests have shown how badly primacord can damage hardware on the inside of the transition section.

Shaped charges less destructive

Shaped charges have the same cutting action as primacord but not the destructive side effects of flying debris. However, not enough research has been done on them so that they could be recommended unreservedly for separation designs.

Mechanical "zippers" or latches may also be used. These pull away at the proper time and leave the two stages mechanically separated. Such a design is quite complex, though, since powerful springs and roll-up are needed to pull away metal elements. Furthermore, the mechanical action must be triggered by an explosive squib or bolt, and so we're right back with the undesirable effects of explosions (though these are less destructive now).

Still and all, explosive bolts have become more reliable and offer a fast and fairly simple way of rending apart two metal sections. The testing of these bolts, of

more on next page

FIGURE 3: Explosive bolts used for stage separation usually are hollow aluminum containers that can be screwed or riveted into the structure and may have a load-carrying function. They may use dual ignition squibs and a single charge.

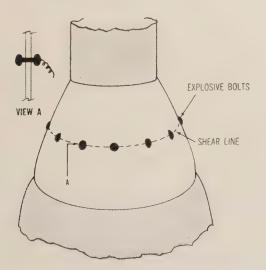
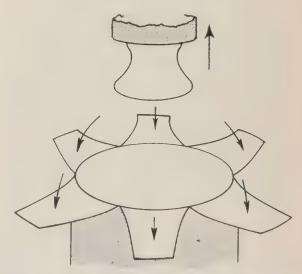


FIGURE 4: In "flower petal" separation, metal petals open up as the upper stage fires. The petals normally are load-carrying members. They should be hinged and held together by a hoop that in turn is split and held by an explosive bolt. Slip joint is an alternative design.



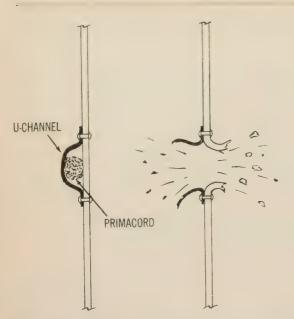
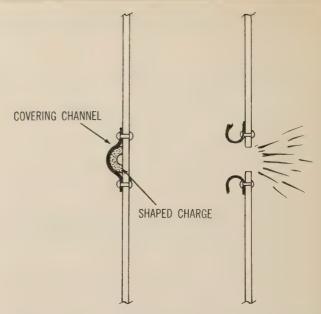


FIGURE 5: Exploding primacord rips metal. The pressure wave it produces and/or the flying metal fragments may damage sensitive parts within the interstage com-



partment, such as the rocket nozzle of the upper stage. Shaped charges, on the other hand, leave a clean cut in the metal and cause little fragmentation.

course, is a perennial headache. No matter how many explosive bolts are batch-tested, you can never be sure the one bolt you are actually using is going to explode.

A more sophisticated—i.e., less sudden—separation design is needed when the upper stage is to fire some time after separation. In this case, the mother stage must boost the next stage to the required separation

velocity. Then, acting on some signal (perhaps from lower-stage shutdown), small auxiliary rockets might pull away the upper stage, while other, retro-firing small rockets might slow down the lower stage and make sure it won't interfere with the continued flight of the upper.

Slip joint for smooth pull-away

If the upper, or carried, stage is to pull away smoothly from the mother stage, some slip joint of "flower petal" arrangement is needed (Fig. 4). If only lower-stage retro-rockets are used, as for the separation of Vanguard's second and third stages, the upper stage will simply be carried off by its own momentum. Small auxiliary rockets to give the upper stage more velocity should be provided whenever larger stages are to be separated.

In such delayed separation, there is also the problem of attitude control. The carried stage must have not only auxiliary rockets to pull it away until the main engine fires but also small pitch, yaw, and roll jets to stabilize it during the separation period.

Rockets alone may be dropped off

Several multi-stage vehicles using large rockets do not separate into complete stages but rather drop off some of the rockets. Since a rocket vehicle's efficiency depends largely on the mass ratio, it's obviously an advantage if several of its engines are housed in something less than a complete stage structure and drop off

THOR'S INTERIOR just after the nose cone has separated.

Stage Math

The maximum flight speed of a single-stage rocket vehicle is limited by the propulsive energy that must be expended—throughout the powered flight—upon the structural mass (tankage, plumbing, accessories, etc.). If we ignore gravity losses, or retardation, the maximum burnout velocity (in fps) is given by:

$$V = -cln(1 - z),$$

where c is the exhaust velocity (in fps), which is about 10,000 fps for high energy propellants and z is the mass ratio, or the ratio of propellant mass to overall vehicle mass.

For a rocket vehicle made up of n stages, the burnout velocity of the last stage is:

$$V = -cn[a(1 - I) + I],$$

where a is the ratio of empty weight to gross weight for any stage and I is the payload ratio, or the weight ratio of the carried load (upper stages and payload) to the carrying stage under consideration. For a well-designed present-day vehicle, typical values of a lie around 0.2, while the values for I might be around 0.1 for the first stage, or booster, of a large three-stage craft and around 0.05 for the third stage.

after shutdown. In a four-rocket vehicle, two of the rockets, for example, might drop off after the boost period. The two cruise rockets then take over, with the vehicle of course weighing much less than it did on takeoff.

However, it isn't at all a simple matter to split off several big rockets in flight—there's the problem of all the plumbing, valving, flow controls, and electric connections that go with a rocket. If the trick can be done, the rewards are great, but it's still quite a trick. Because of security classification, little more can be said than that elaborate systems of check valves and pull-away disconnects are necessary to prevent propellant and pressurizing gas losses. Naturally, "clanking" and perturbation must be prevented, too.

Lower stage is "dragged" away

When separation takes place at an altitude at which there is still an appreciable atmosphere, differential air drag can be used. When the mother stage is burned out and actually an empty shell, its drag will be higher than that of the more densely loaded stage above it. If the upper stage is held in a simple slip or sliding joint, separation will occur as the lower stage is slowed down and "dragged" away from the upper. This drag separation scheme has been used for some years in the case of small high altitude rocket vehicles.

With solid propellant rockets, staging and separation generally are much simpler. Since solid rockets have no plumbing and, as a rule, a simple ignition process, you don't need much in the way of electric or mechanical disconnects.

Over the last few years, NASA's Langley Field-Wallops Island rocket test group has built up a brilliant record of solid rocket separation. Often its vehicles have

had as many as five or six stages. Separation usually has been achieved by simply letting the upper stage biast into a separation compartment and blow itself tree.

It's true that such a simple scheme can result in severe perturbations. It works best with vehicles whose thrust levels rise quickly and that can achieve high thrust-weight ratios, so that the getaway is fast and there is little need for stabilizing fins or other auxiliary control devices.

Spinning stages pose new problems

When very precise flight paths are required for multi-stage solid rocket vehicles, a smoother separation scheme might have to be used to prevent an excessive load on the control mechanisms. However, these solid rocket designs are still so relatively uncomplicated that some simple expedient such as slip joints and plain blast doors will prove adequate.

Stage separation in solid rocket vehicles becomes more complicated when an upper stage is spun, as is the case with Vanguard's third stage. The spin counteracts thrust misalignments and insures stability. The designer is faced with the extra problem of providing a mechanism that will both spin up the rocket and release it when the lower stage slows down, so that the upper can sail on out of its "can" (Fig. 6).—End

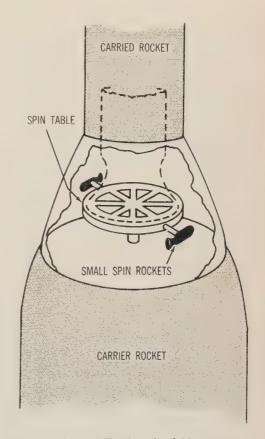


FIGURE 6: Spin stabilization is fairly common with solid propellant upper stages. It gives an extra twist to the problem of separation design, since some way must be found for clamps to release the rocket resting on the spin table at just the right moment.

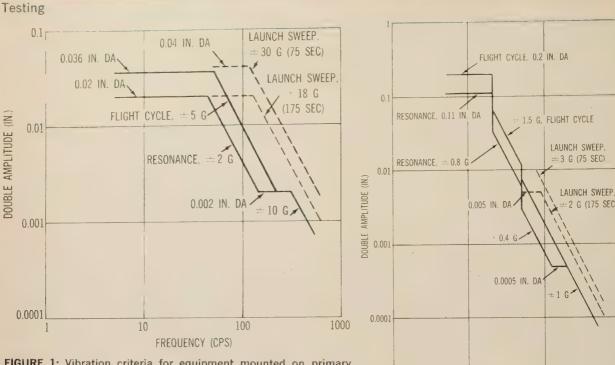


FIGURE 1: Vibration criteria for equipment mounted on primary missile structure (left) and for resiliently mounted items tested without vibration isolators (right).

Vibration-proofing

for missile electromechanics

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Of all the environmental stresses to which equipment in today's advanced vehicles is exposed, vibration is the one hardest to simulate in tests. Here is a report on how the vibration test problem was licked on the Snark missile program.

by R. S. Dillon, Senior Engineer, Electronic Systems & Equipment Dept., Nortronics Div., Northrop Corp.*

THE VIBRATION and shock problems of electromechanical equipment can't be overcome by standardized design. The only solution is to test the hardware under simulated environmental conditions. This course was followed in the development of the stellar-inertial guidance system for the SM-62 Snark intercontintental missile.

FREQUENCY (CPS)

Because of pressing delivery schedules, a special test sequence had to be set up:

• a "design test" to spot vibration problems before the manufacture of production equipment,

*Nortronics Div., Northrop Corp., 222 N. Prairie Ave., Hawthorne, Calif. The author wishes to thank R. A. Lindsey, L. P. Mathews, and F. B. Safford, as well as other members of the technical staff of Nortronics, for their help.

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1000

• a "flight justification test" to prove out the continuing changes made in the equipment in the course of the flight test program,

• a "qualification test" to check out the end items. Roughly 2½ systems were available for destructive testing—a preprototype for the design test, the same system, supplemented by prototype hardware, for the flight justification test, and a complete production system for the qualification test.

A uniform test spec was used throughout the test program. Its parameters were wave shape, amplitude frequency, and time. Generally speaking, this "criterion" was a conventional sine-wave type consisting of logarithmic frequency sweeps and fixed-frequency testing (resonance) from five to 600 cps at various amplitudes (Fig. 1).

Zero-length launch was simulated

The amplitudes were derived from Snark flight test data. Test duration per axis and frequency range were based on Mil-E-5272A. A 5-600-cps launch frequency sweep was added to simulate the effect of zero-length launch. Total test time per axis was 3.2 hours.

Since some resiliently mounted items could not conveniently be tested as normally installed, a special spec simulating the frequency response under normal installation conditions was derived for these units, which were hard-mounted on the shaker. Flight cycling and launch sweep rates were the same for these items and those mounted on the primary structure (Fig. 3).

The test procedure was divided into hardware operation and environmental programing. First the hardware had to show in operation that it met the missile requirements. Any deviation from the operational tolerance limits had to be corrected. In environmental programing, an item typically was exposed sequentially to the test criteria until all three axes were tested. Design corrections were made whenever a failure was noticed. Upon completion of the initial three-axes test, a repeat test was run on any reworked part for as many axes as necessary. A failure was defined as any repeatable functional out-of-tolerance or structural fatigue effect attributable to the simulated vibration.

The hardware of the Snark guidance system is of conventional sheet-metal construction using cold forming and riveted joining. Important circuits are grouped in removable subassemblies. There are 46 assemblies of varying complexity. All of them went through the three test phases. For the purposes of this report, we will restrict ourselves to 17 of these assemblies, or modules, all of them resiliently mounted. For the sake of brevity we will also pass over the extensive parts surveillance program set up to spot random failure due to production variability.

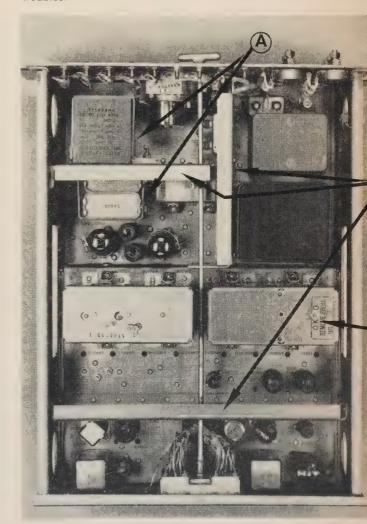
All of the 17 modules except one were involved in the 37 failures that occurred during the design test. The average failures per module were 2.18, and the failure rate per hour was 11.6 (Fig. 4). This high failure rate was due to the large relative motions of the assemblies and their parts inherent in the design method. Over the range of 10-60 cps, relative displacements of \(\frac{1}{8} - \frac{3}{8} \) in. were common. Typical failure effects were fatigue of the chassis structure or the cantilever support bracketry, broken wires or capacitor leads, shorted or

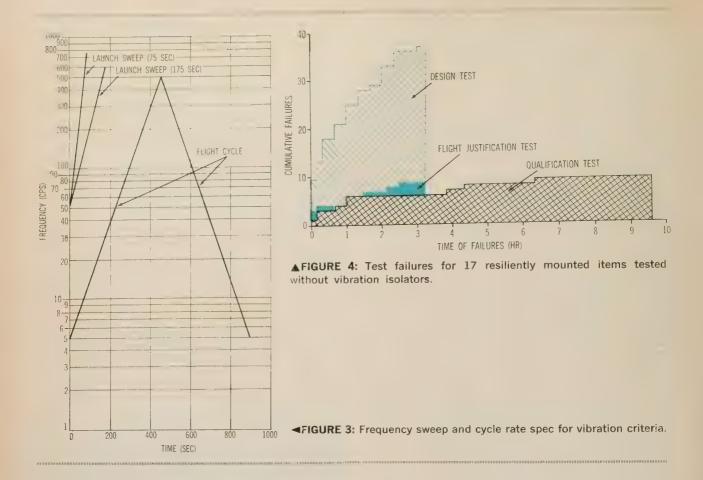
noisy tubes, modulating tuning forks, and relay contact chatter.

Most of these failure problems were overcome by increasing the stiffness and damping of the chassis and mounting structure. Deep beam or rib sections were added to the chassis, unsupported ends of cantilevered parts were fastened, stress plates were added to subassemblies, cable connectors were potted, and clamps were added to cable harnesses and to parts supported only by leads. Highly fragile parts were mounted on isolators or replaced. Items with natural frequencies that coincided with the frequency of the mounting structure were detuned through the use of new isolators or materials.

In the flight justification test, five of the 17 modules accounted for all the nine failures. Like this total of failures, the failure rate per hour was roughly 75 per more on next page

FIGURE 2: On flight control computer, unsupported ends of cantilever-mounted parts were restrained (A), three structural ribs were added (B), cantilever-mounted sub-assemblies were restrained (C), and clamps were added to the cable harness (not shown) to overcome vibration troubles.





cent below the value for the design test. The failures in the flight justification test were due mainly to changes in the equipment that were made after the design test had been completed.

In the qualification test, the total of failures again was nine. However, the failure rate per hour was reduced by about two-thirds to 0.91. Six modules accounted for the nine failures, which were traced to wiring fatigue due to the long test time, design changes made since the flight justification test, and the variability of both electric and mechanical parts.

Computer shows design fixes

The kind of fixes that resulted from our vibration tests is shown by the typical example of the system's flight control computer (Fig. 2). Structural amplification in this unit caused wire breakage, intermittent tube operation, and noise in the output voltages. To overcome these effects, we restrained the cantilevered subassemblies and the unsupported ends of cantilevered parts and added three structural ribs as well as clamps.

There are three types of structural designs that the engineer can use to get better vibration resistance from his electromechanical equipment: rigid assembled structure, cast structure, and damped structure.

• Rigid assembled structure implies a sheet metal construction providing high moments of inertia. Such design features as deep beams, welded joints, low CG, and compartmentalization are used, to name only a few.

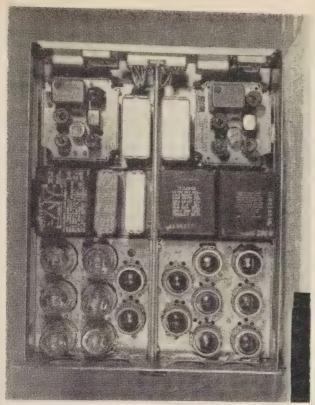
Figure 5 shows a digital power amplifier from the Snark guidance system as an example of a module designed from the start as a rigid assembled structure. The amplifier features deep beams, egg-crate construction, CG mounting for heavy parts, like transformers and noise filters, clamp supports for large tubular capacitors, and clamping-style shields to support vacuum tubes. This unit has proved highly successful in all its tests, including several missile flight tests.

• Cast structures of aluminum alloy also use deep beams and egg-crate construction and also provide high moments of inertia. On the other hand, they have somewhat better damping properties than rigid assembled structures. Another of their advantages is dimensional stability, often needed for certain precision devices. However, castings are relatively expensive at low production rates and have longer production lead times than rigid assembled structures.

Chassis stood up to vibration

Figure 6 shows the cast chassis of a completely selfcontained digital computer in the Snark guidance system. The unit, a high density design using semiconductors and printed circuits, has its own magnetic memory drum. Despite its complex configuration, it met all environmental requirements without trouble. In vibration tests, its gross natural frequency was barely detectable -a slight resonance was noted at 525 cps. Equally good results were gotten in several flight tests.

 Damped structures reduce the gross amplification of excitation at resonant frequencies and represent a relatively unconventional approach. The traditional antidote to vibration is to design for maximum stiffness



ADDED BEAM, raised deck, tube shields, and relocated tube clamps licked vibration on dc power supply.



FIGURE 6: Airborne digital computer and its cast chassis.

and/or mount sensitive parts on isolators. In this way, the structure is detuned away from the resonant frequencies of the individual parts. The effect is the same as if frequency control were used in the design.

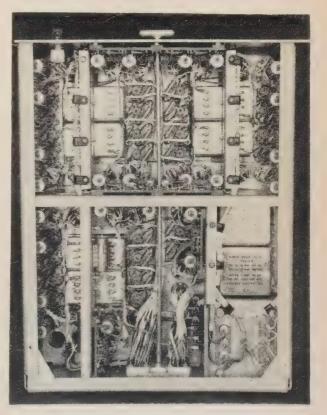
High damping properties needed

The unconventionality of damping as a vibration control parameter is shown by the fact that not too much damping can be achieved with the usual structural materials of electromechanical equipment. These have low damping properties, and obviously materials with high damping coefficients are what's really needed. The important advantages of damped structures over rigid assembled and cast ones are easier fabrication, low weight, and easier accessibility and maintenance.

Nortronics has been working on advancing the state of the art in the field of damped structures. As we expected, progress has been slow so far. However, we have made some interesting breakthroughs. To date, we have studied damping as applied integrally with the structure in the form of sandwiches or laminates and individual damping units for use in suppressing motion as necessary. The second approach up to now has yielded the better results.—End

References—C. T. Morrow, "Techniques for Design to Shock and Vibration Conditions," 24th Shock & Vibr. Symp., San Francisco, Calif., Nov. '57. R. C. Wilcox, "Qualification Policy for Airborne SM-62 Weapon System Program;" Northrop Report NAI-54-418 Rev. 3 ('54), R. L. Baugh, "Environment Testing of Production Equipment;" 25th Shock & Vibr. Symp., Cambridge, Mass., Sept. '57. F. B. Safford & W. S. Inouye, "Vibration Fragility Considerations in the Design of Electronic Equipment;" 25th Shock & Vibr. Symp.

FIGURE 5: Digital power amplifier is an example of a rigid assembled structure.



Accessory Components



EFFECT of hydrazine on elastomers in 70 hours' immersion at 250 deg F.

Breakthrough needed for extreme environment

fluid sealing

Sealing is one of the big problems in designing systems for operation from -400 to +1000 deg F. In the end, the solution probably will have to come from a major break-through in polymer technology or the development of heat-resistant "elastomeric-inorganic" composites.

by A. A. LaPera, Materials Laboratory, Wright Air Development Center*

ELASTOMERIC O-RING SEALS are being overlooked by the designers of systems that operate at 400 deg F and higher. These designers can, of course, point to poor performance experience with such seals at high temperatures. However, new seal materials and designs are being developed that should be considered before they settle on metal seals as a compromise.

(1) Rubber Preducts Section, Organic Materials Branch, Materials Laboratory, Wright Air Development Center, Wright-Patterson AFB, Ohio. This is a condensation of a paper "Fluid Sealing in Extreme Environments," given at the SAE National Aeronautic Meeting, New York City, March 31-Apr. 3, '59.

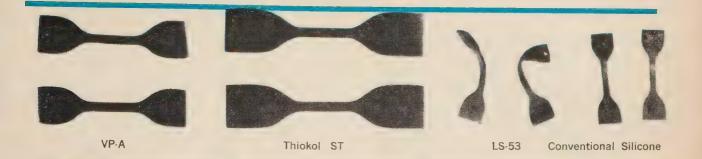
Elastomeric materials have been made much more stable. Most important are certain of the flourine-containing elastomers:

• Fluoroacrylates—These have average original properties, poor low temperature characteristics, and excellent resistance to diester-based engine lubricants such as di-2-ethylhexyl sebacate. They exceed the 275-deg F limitations of the butadiene acrylonitrile seals formerly used. The fluoroacrylates include poly-1, 1-dihydroperfluorobutyl acrylate (Fluoro Rubber 1F42) and perfluoromethoxy 1,1-dihydroperfluoropropyl acrylate (Fluoro Rubber 2F42).

• Copolymers of Trifluorochloroethylene and Vinylidene Fluoride—These have exceptionally good original properties and outstanding resistance to fuels, petroleum-base lubricants, and corrosive chemicals. However, they are hard to fabricate and tend to "cold-flow," so their usefulness in seal applications is limited. The co-polymers include Kel-F 3700 and 5500².

• Fluoroalkyl Silicones—The LS-533 silicones that meet Mil-R-25988 show a rather uniform balance of mechanical properties over the range of —90 to +500

⁽²⁾ Registered trademarks, Minnesota Mining & Mfg. (3) Registered trademark, Dow Corning.



deg F and have average fluid and solvent resistance, but tear and abrade easily. Seals of these silicones should be used in rotating or reciprocating applications only after very careful study.

• Copolymers of Perfluoropropene and Vinylidene Fluoride—These materials, when properly compounded to Mil-R-25897, are serviceable up to 600 deg F, with outstanding resistance to a wide variety of fluids and environmental extremes. They include Viton A⁴ and the more recent and highly viscous Viton A-HV⁴.

Lab test results are contradicted

Unfortunately, lab test results do not always reflect service experience. For instance, Viton A has a brittle point of —30 deg F, yet it has proved perfectly adequate as a static and dynamic seal at —65 deg F. Why? No one knows. Obviously there is an urgent need for better correlation of physical property data with performance.

At WADC's request Boeing is studying this very problem, running a series of evaluation tests designed to simulate the adverse mechanical conditions of various fluid systems operating over the ranges of —65 to +700 deg F and zero to 5000 psi. An important phase of this program is the study of seal-and-matched-groove

(4) Registered trademarks, duPont de Nemours & Co.

configurations that might offset particular material deficiencies.

No definite relationship has yet been established between physical properties and performance. We do know that there is a connection between seal life and compression relaxation (not to be confused with compression set, which is based on the percentage of return of the elastomer after deflection).

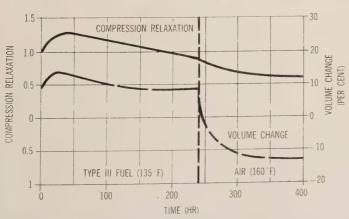
Relaxation scaled as force change

Relaxation can be scaled by measuring the change in force exerted by the O-ring against a sealing surface while immersed in fluid. It is represented by a plot of force vs the logarithm of time.

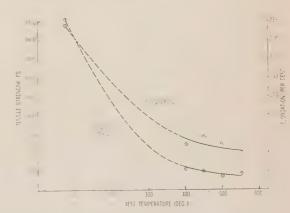
Environmental changes affect relaxation. For instance, the increased force due to swelling aids sealing. However, subsequent dryout during aging results in a loss of the initial seal. Compression relaxation is retarded to some extent by the confinement, volume swell, and thermal expansion. In general, though, it is speeded up by high temperatures and nuclear radiation.

In the case of high pressure (1500-4000-psi) systems, seal designers should take a close look at seal groove cavity, anti-extrusion devices, and the sliding seal surface. Many groups report that very smooth grooves

more on next page



EFFECT of immersion on compression relaxation and volume change (left) and of temperature on physical



properties of perfluoropropene-vinylidene fluoride copolymer seals (right).

Property Changes of Perfluoropropene/Vinlyidene Fluoride Copolymers

	Tensile	Elongation	Hardness	Volume Change
Original	2800	240	70	
In OS45-1	450	80	70	23
70 hr at 500 deg F	1700	180	65	1,5
In GE81406	1100	40	80	-3
70 hr at 500 deg F	1900	0	99	-15
In air	1170	90	70	-4
70 hr at 550 deg F	500	50	80	-18
In isopropylbiphenyl 70 hr at 400 deg F	2500	950	60	5.6

(less than 32 RMS) result in O-ring leakage due to pumping of the seal in the groove. Likewise, too smooth a sealing surface (less than five RMS) results in O-ring spiraling caused by a restricted fluid flow path. At more than 20 RMS, you get O-ring abrasion.

Failures occur above 1500 psi

In general, most seal failures take place when the system is pulsated above 1500 psi. The increased clearances arising from the pressure surges permit the Oring to extrude partially, and you end up with an "extrusion nibble," or cutting-type failure.

Virgin Teflon⁴ anti-extrusion devices, better known as backup rings, have been used up to now to counteract O-ring extrusion. But increased temperature and pressure ranges have made them less useful. Apparently both the material and the configuration of the backup ring affect the maximum seal life. Among the many different combinations that have been tested, a special 0.1-in.-thick, single-turn, scarf-cut ring showed up particularly well. It was made up of a composite of Teflon, aluminum-silicate-type fibers, and molybdenum sulfide. The formula proved extremely resistant to wear and increased O-ring life.

Lasted over 107 hours at 400° F

WADC recently evaluated some special backups to see how they would stand up with 85 Shore A Viton A-HV O-ring rod seals. Four backups (two on each side of AN 6227-19 O-rings) in special grooves were pulsated from zero to 3000 psi at 42 cpm in phase with rod cycling over a four-inch stroke. In a MLO 8200 (silicate-ester-base) hydraulic fluid at 400 deg F, the seals lasted over 107 hours. At 550 deg F and 50 cpm, they endured for more than seven hours.

Republic Aviation reports it has cycled 85-95-durometer Viton O-rings with Versilube F-50⁵ at 680-730 deg F with a similar backup arrangement. With short strokes at 300 cpm, the seals endured 160,000 cycles.

The upper temperature limit was set by the backups and not by the O-rings.

Reports from other sources indicate that both Viton A and A-HV are compatible with most of the experimental high temperature hydraulic fluids now under consideration, such as napthenic oils, silanes, and polyphenylethers. Generally the seals can take 70 hours at 500 deg F, 24 hours at 550 deg F, and about six hours at 600 deg F. In most tests, the Viton A-HV compounds proved superior. Perhaps the number of cycles could be increased in tests in a completely closed system in which oxygen is excluded by an inert nitrogen atmosphere.

Metal seals for use above 400° F

On the basis of limited pneumatic system testing, WADC believes the combination backup and the Viton A-HV O-ring show promise for 400-deg F pneumatic rod seal applications. AN 6227-19 O-ring seals made from a special compound were lubricated with Templube 138 and pulsated from zero to 2500 psi at 36 cpm over a four-inch stroke. The first failure occurred after 58,000 cycles.

This failure was attributed to dc compression fatigue rather than the normal occurrence of compression set, wear, and extrusion nibbling. Pressurized air permeates the seal, cannot escape as fast as the system pressure is released, and so produces surface cracks and splitting.

For 400 deg F and above, most of the work is being done on metal seals. A major effort has been devoted to the development of flight control actuator rod seals, since a failure of just one of these seals could deplete the fluid reservoir or even start a fire.

Many seals made of tool steel, graphitar, meehanite, stainless, etc., have been tested in simulated flight control environments—with only limited success. Metal seals are extremely sensitive to the surface finish of the mating component, axial deflection, fluid lubricity,

⁽⁵⁾ Registered trademark, General Electric.

vibration, and temperature gradients. With dynamic seals, drag and breakout friction are often excessive, especially after storage.

A compromise that has worked in special applications is to use metal contracting rings or a pressure drop bushing with a controlled leakage path. This arrangement is then followed by a positive, low pressure, elastomeric O-ring rod seal. The only apparent drawbacks are the extra weight and complexity of such a system.

Elastomers preferred to metals

There is little doubt that metal seals will continue to be studied extensively for use above 400-600 deg F until suitable elastomeric materials are developed. But many experts agree that they would prefer elastomers because of their many inherent advantages.

Propulsion systems pose the most severe sealing problems even under static conditions. For instance, with high energy fuels based on alkyl boranes, the most severe environment occurs during air aging following fuel immersion. Wyandotte Chemical recently discovered that the exothermic reaction pushes the elastomer temperature up to over 1000 deg F and results in a volume swell of over three per cent. This is then followed by air aging temperatures of over 450 deg F. A completely satisfactory seal material to take these temperatures has yet to be found. A special Viton A-HV compound shows the best balance of physical properties so far, but it still is not the answer.

Bipropellants raise new problems

Bipropellant systems are a challenge to both materials and design engineers. For instance, compounds of SBR (styrene butadiene rubber) and Hydropol V⁶ (hydrogenated butadiene polymer) are compatible with hydrazine up to 250 deg F for a maximum of five days. Kel-F 5500, Viton A, and butyl elastomers resist IRFNA (inhibited red fuming nitric acid) for a week—but only at room temperature. Higher temperatures accelerate the elastomer degradation. The compatibility

(6) Registered trademark, Phillips Chemical.

of elastomer with other potential bipropellants—liquid fluorine, nitrogen tetroxide, chlorine trifluoride, unsymmetrical dimethyl hydrazine, JP-X, etc.—is being studied by Connecticut Hard Rubber under a WADC contract.

The most difficult sealing problems crop up in cryogenic systems. In these, some components (usually pneumatic solenoid valves) must operate with minimum breakout force, low amplitude, and immediate response over a range of —320 to +500 deg F. Teflon, Kel-F elastomer, and composites of these two materials with asbestos, stainless, Inconel, etc., have been tried. But poor resistance to cold flow, extremely close tolerances, and the high compressive stresses needed to make a seal limit their usefulness.

Seal is sensitive to temperature

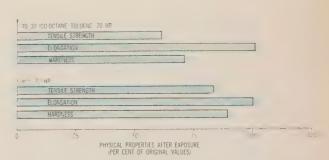
Under an Army contract, General Electric has developed a temperature-sensitive seal consisting of a Neoprene W⁷ gasket backed by an Invar insert that shows promise. It uses the temperature drop accompanying the confinement of a liquid gas to stress the gasket and maintain a positive static seal at temperatures down to —297 deg F. The gasket stress increases as the temperature drops and is independent of the assembly installation load. This principle, along with several others, is being followed up under a WADC contract by the Bureau of Standards, which is developing a static and dynamic cryogenic seal for temperatures down to —452 deg F.

Armour Research, also under a WADC contract, is developing an essentially inorganic seal material that has the desirable characteristics of an elastomer as well as temperature resistance to at least 1,000 deg F. Several composites consisting of a sintered stainless steel fiber network filled with various soft, ductile phases have been used to fabricate static seals. These early developments show promise. Other approaches now under consideration for seal designs involve metallo-organic compounds, inorganic polymers containing boron, nitrogen, and phosphorus, etc., and compressible ceramics.—End

(7) Registered trademark, General Electric.



RESISTANCE of perfluoropropene-vinylidene fluoride copolymer seals to fluids at 550 deg F and fuels at 400 deg F. Volume changes were about —15 per cent in air.



+1.5 per cent in OS 45, +0.5 per cent in ML-0-8200, +31 per cent in 70/30 iso-octanetoluene, and +4 per cent in JP-5.

Acoustic fatigue:

key element in high Mach design

Turbojet engines have introduced a new factor that must be considered in designing high Mach structures: fatigue due to the intense sound pressures generated by engine exhaust flow. For future designs, in fact, this effect can be so critical as to be a major consideration in choosing the engine locations.

by Gordon L. Getline, Design Specialist, Convair-San Diego¹

CATASTROPHIC FAILURES can occur when conventional light aircraft structure is exposed to the acoustic energy generated by the exhaust of high thrust turbojets. To counteract this danger, the designer must fatigue-proof his structure on a statistical basis.

How important fatigue has become is shown by the fact that it was this parameter which alone established the stress levels of the major components in the Convair 880. And the two causes of fatigue characteristic of modern aircraft are random transient inputs (such as gust loads) and acoustic energy. There is no reason to believe that fatigue considerations will be any less important for supersonic transports.

For acoustically induced fatigue, the major energy source on the present jet transports is the engine exhaust. The noise it generates usually is wide-band and has no discrete components. A generalized pressure vs frequency spectrum for jet noise is characterized by a smooth curve of upward convexity. The absolute magnitudes of the pressures and the frequency bandwidth containing the maximum energy depend on a number of parameters related to exhaust nozzle design and gas

(1) Convair Div., General Dynamics Corp., 3165 Pacific Highway, San Diego 12, Calif. This is a condensation of a paper, "Some Considerations Relative to Acoustically Induced Structural Fatigue in a Supersonic Transport Aircraft," given at the Annual IAS Meeting in New York City, January '59.

flow and to the angular and radial location of the observation station with respect to the nozzle.

In general, the sound pressure levels in the wing areas of today's subsonic transports using engines in the 10,000-lb-plus thrust class are on the order of 160-165 db (Fig. 1). This range corresponds to an rms pressure, over a bandwidth from 20 to 10,000 cps, of about 0.28-05 psi. By themselves, however, these figures are of no use to the structural designer.

Fatigue studies are directly concerned with repetitive stress reversals. Hence, the acoustic pressure data must be examined in terms of peak pressure amplitudes and their frequency of occurrence. For the 880 wing structure, for example, statistical analyses were made of the near-field acoustic pressures generated by the GE CJ-805 engine (Fig. 2). These yielded a characteristic curve within relatively narrow limits and independent of frequency range and observation station.

Next we must consider the response of a lightly damped structure to the input we have described.² Exposed to random acoustic excitation perpendicular to its face, a panel will vibrate predominantly in its normal modes. With this type of excitation, there is pressure phase correlation over the entire surface of the panel. If the panel is lightly damped, the significant responses will be in the fundamental modes and will be characterized by pronounced beats.

Grazing can cause standing waves

However, if, the excitation is applied at grazing incidence, which is closer to what actually happens in operation, the situation is somewhat different. Traveling waves will be generated in the panel and, at some frequencies, reflection from transverse supporting frames will result in standing waves. Stress maxima will occur as a result of the latter.

The greatest stresses may not occur in the lowest modes, and stress levels of equal significance may be generated in a number of modes as a function of the

^{(2) &}quot;A Study of the Response of Panels to Random Acoustical Excitation;" NACA RM L55E13C ('55).

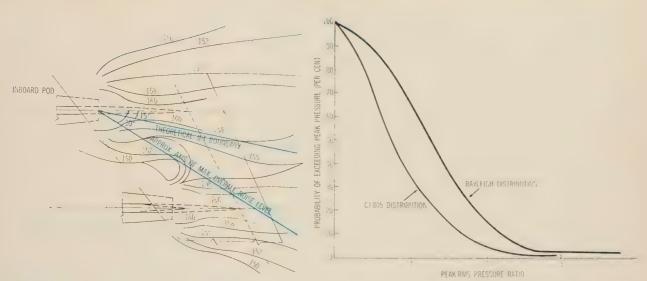


FIGURE 1: Plan view of acoustic pressure field around 880 wing at takeoff (referenced to 0.0002 ubars).

FIGURE 2: Probability curve of jet-exhaust-generated near-field acoustic pressures.

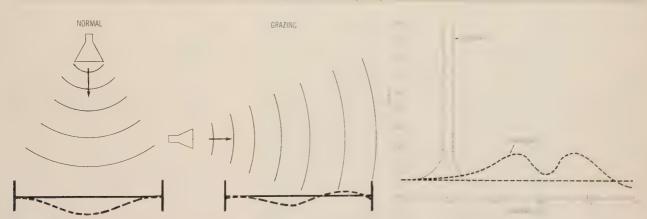


FIGURE 3: Effect of incidence on panels (left). At normal incidence, normal modes are excited and fundamental responds most strongly. Grazing pressure excites standing waves, strongest response is a function of pres-

sure phase correlation. Right: Relative stress magnifications at grazing incidence of ½-in. honeycomb panel with 4.5-lb core and 1.24 psf surface density and of 0.08-in. isotopic sheet with 1.15 psf surface density.

occurrence of pressure phase correlation over the length of the panel (Fig. 3). As in the case of perpendicular excitation, the responses will be characterized by beats from the randomly varying pressure fluctuations.

A structure exposed to jet noise can't be effectively detuned to prevent inordinately high resonant stresses (as would be possible if the noise source had discrete components). Therefore it must be designed to accept and dissipate the imposed pressures without failure by high rigidity and high damping. The high rigidity provides a low forced stress level, because of the high section modulus, while the high damping results in a low stress magnification at resonance. Bonded aluminum alloy structure admirably meets the needs for low weight and high rigidity and also provides significant damping (Fig. 3).

Acoustic fatigue-proofing of today's subsonic transports is governed by two factors:

- Operating time at high thrust, which entails high noise levels, is limited.
- The engines are so installed that local wing skin temperatures due to jet exhaust are less than 300 deg F.

Maximum thrust at takeoff is normally maintained for about one minute. Then a reduced thrust climb setting is established, and the acoustic pressures generated by the engine exhausts then decrease significantly. When cruise thrust is set up a few minutes later, a further marked pressure drop occurs. Under cruise conditions at 25,-40,000 ft, exhaust-generated acoustic pressures are on the order of 10 per cent of those generated at takeoff. So, if a block time of two hours is assumed.

more on next page

significant acoustic pressures will have been generated for less than one per cent of the time. This percentage may also be applied to the useful operating life of the aircraft.

Preliminary studies at Convair-San Diego indicate the Mach 3 transport will have a high-fineness-ratio body, a low-aspect-ratio ring, possibly canard control surfaces, and a gross weight of 400-500,000 lb. Figure 4 shows three possible designs; the one with a delta wing far back on the fuselage appears best from the standpoint of fatigue induced by engine exhaust noise.

The engines for these transports would not need afterburners so long as Mach 3 does not have to be exceeded. Some thrust augmentation, though, might be needed for takeoff. Bypass engines (turbo-ramjets) are indicated above Mach 3.

The Mach 2-3 engines will probably be in the 20,-30,000-lb thrust class, with static sea level mass flows on the order of 300 pps. Nozzle pressure ratios will vary from about 2 at sea level to 40 or more at maximum Mach number at around 65,000 ft. The diameters of the engine exhaust nozzles will be on the order of 4-6 ft—roughly twice as large as on current commercial engines.

The mission profile shows that maximum or near-maximum thrust will be held for about 100 per cent of the operational time (except for final letdown), as against one per cent for today's subsonic jets (Fig. 4). This startling figure is offset to some extent by speed and altitude considerations: While overall noise levels of 170 db (0.9 psi rms) may be generated at sea level static, at cruise these levels will drop to around 100 db (0.0003 psi rms). However, these levels could rise markedly if new alloys permitted higher exhaust temperatures.

Because of the skin temperatures at Mach 3 and beyond, the day of the aluminum alloy structure is probably over. It appears that either titanium or steel alloys will be used at these temperatures; stainless steel is unofficially preferred at present.

Lightweight stainless steel sandwich structures can be made. (Adhesive bonding can't be used because of temperature limitations.) Brazed structure is used in the B-58, on which it provides a high strength-weight ratio, good insulating properties, and high oxidation and good fatigue resistance. Welding offers one of the best and cheapest methods of joining such materials.

Unfortunately, spot-welded stainless steel in skin gages on the order of 0.025 in. doesn't have very good fatigue resistance. If this type of construction is to be used, ways would have to be found to introduce added damping. In any case the cost per pound of airplane is going to increase greatly.

Boundary layer has noise effects

Another factor that may become important in the future is boundary layer noise. Briefly, the problem is that random turbulence in the boundary layer may excite the skin over which it passes. There are no test data today on such noise, and at least two of the theoretical treatments of the problem are in conflict.

Nevertheless, it is interesting to extrapolate subsonic data to the supersonic case. If a flight condition of Mach 3 at 65,000 ft is assumed, we get overall rms pressures of four psi (183 db), with possible significant peak pressures of 12-16 psi.³ Furthermore, the frequencies of maximum energy content will move upward, where they might more easily couple with a light, stiff steel structure.—End

⁽³⁾ W. W. Willmarth, "Space-Time Correlations and Spectra of the Wall Pressure in a Turbulent Boundary Layer;" Galcit contract NAW-6517 ('58). P. F. R. Weyers, "The Vibration and Acoustic Radiation of Thin-Walled Cylinders Caused by Internal Turbulent Flow;" Galcit '59.

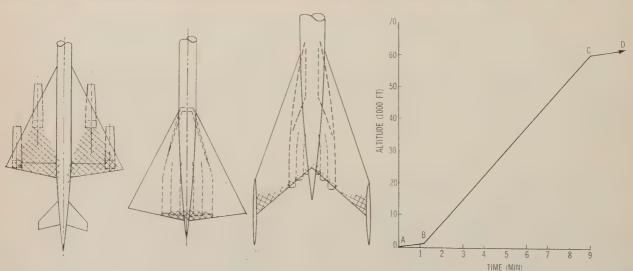


FIGURE 4: Possible configurations for supersonic transport (left). Cross-hatched areas show critical jet-exhaust-generated acoustic pressure areas. Right: Possible mission profile for Mach 3 transport—(A) each engine at maximum sea level static thrust of about 20.000 lb; (A-B) acceleration in level flight to Mach 0.9; (B) each

engine at maximum thrust of about 39,000 lb at Mach 0.9; (B-C) climb at maximum available thrust, giving an average speed of Mach 1.7; (C) acceleration to Mach 3 at maximum continuous power and initial cruise altitude of 60,000 ft; (C-D) slow climb to cruise altitude of 70,000 ft.

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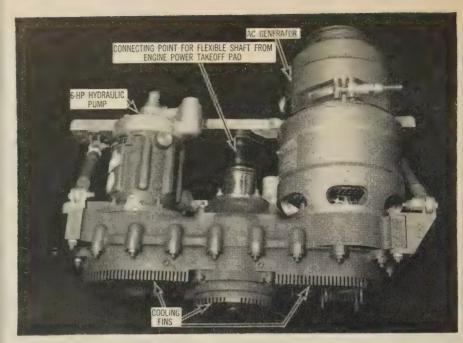


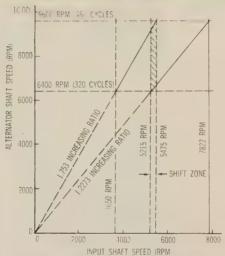
by Irwin Stambler

Associate Editor

Two-speed drive simplifies T-38 accessory system

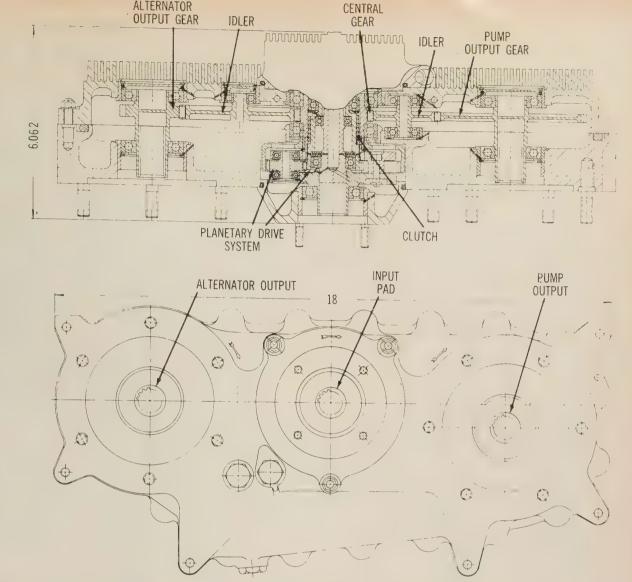
NORTHROP'S T-38 Talon trainer and N-156F fighter both use a unique twospeed automatic-shift gear box in their accessory drive systems. Engineers at the firm's Norair Div. decided on this unit to save weight and cost and improve reliability when it was determined that only five per cent of the total load required strict frequency regulation at 400 cycles. For the speed range of the GE J85 engine, the two-speed gear box was found good for driving an eight-kva alternator at speeds which would deliver 320-480 cycles over a range of engine speed from idle to full rpm. The unit also drives hydraulic pumps that supply all hydraulic power. Designed by Technical Products Div., Waste King Corp., 5550 Harbor St., Los Angeles, Calif., it weighs 29.5 lb. Engine input speeds are 3650 rpm min and 7822 max; alternator speeds, 6400 rpm min and 9600 rpm max; and hydraulic speeds, 3771 rpm max and 2514 rpm min.





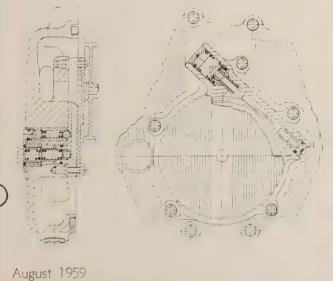
PLAN VIEW of drive assembly (above). Two of these units are used per plane, one for each J85 engine. Center: Operating curve for Waste King gear box. Below: Two halves of the gear box's housing, made from magnesium castings with steel inserts for the bearings. The gear box is air-frame-mounted.





IN THE GEAR BOX, the input spline is integral with the planet carrier of a planetary gear drive that can increase the speed by 1.43. The carrier mounts three planet gears supported by ball bearings. It also has an integral shaft extension that passes through the center of the unit to the opposite side of the box and drives a flyball governor at the input shaft speed. Via an internal gear, the planetary gear drive output goes to a central gear mounted directly in the gear box surrounding a spring-type overrunning clutch. This central gear meshes with

two idlers on each side that, in turn, mesh with the alternator and pump output gears. The clutch lets the output gear run when the planetary drive sun gear is stationary. The flyball governor causes a shift by actuating a brake that locks or frees the sun gear. The governor spring constant is such that the flyweights snap outward at 5450 rpm while the input shaft speed is increasing and inward at 5350 rpm while the shaft speed decreases. A differential of 100 rpm is needed to avoid governor hunting.







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SPACE/AERONAUTICS

Manned space station needs special

"ferries and tugs"

This is the last article in a three-part series on a proposed manned space station system. The two earlier articles appeared in June (p. 52) and July (p. 52).

by S. B. Kramer and R. A. Byers,

Space Vehicle Design Scientist & Staff Engineer, resp., Missile & Space Div., Lockheed Aircraft Corp.*

TWO TYPES of auxiliary space vehicles will be needed for manned satellite operations: a re-entry transport (Fig. 1) to ferry crewmen between earth and space and an "astrotug" (Fig. 2) for assembling the satellite station in space.

The re-entry vehicle, which carries a pilot and three passengers, can be fired to an orbital altitude of 500 miles in 6-10 minutes. Upon arrival, it can operate for a week without taking on any supplies. The return trip to earth can be made in 2-4 hours, depending on the allowable G-loading and structural temperature

The fuselage is made up of frames, stringers, and skins that serve as both structural members and heat reflectors. On the upper aft end of the fuselage is a conventional jet engine with a retractable inlet. Once the vehicle re-enters the atmosphere, the duct inlet extends to admit air to the engine. At an altitude of 25,000 ft, the engine can put out about 5,000 lb thrust at Mach 0.4 to give a 100-nm range.

The re-entry vehicle is equipped with VHF radio

Missiles & Space Div., Lockheed Aircraft Corp., Sunnyvale, Calif. This is a condensation of a paper, "Proposal for the Assembly of a Multi-Manned Satellite," given at the National Meeting of the American Astronautical Society in Washington, D.C., last December 27-30.

equipment for communication with ground-based tracking stations and other vehicles in orbit. This equipment may be operated on either voice or CW with manual or automatic keying. In addition, a radar tracking transponder beacon may be keyed for emergency communications. An infrared communication system is available as a backup.

Two beacons are used for ground tracking: the regular transponder that goes with the radar set and a VHF beacon similar to the Azusa unit carried on most missiles. Two airborne radar sets are used to track other vehicles in orbit. One is mounted on the aft bulkhead and the other on the nose, looking through a hinged door in the thermal skin of the vehicle.

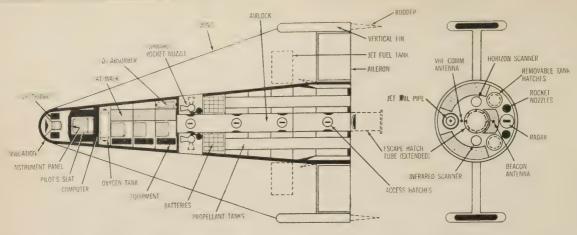
In orbit, an attitude control system keeps the vehicle oriented, with its axis of minimum moment of inertia parallel to the local vertical. Operation is controlled by a reference gyro that, in turn, is erected by a horizon scanner.

Orbital navigation computer used

A navigation computer is used to control orbital flight. It automatically calculates the best trajectory for any desired path and the results form inputs to the flight control system, which controls the magnitude and direction of thrust vectors at the rocket nozzles. For re-entry, a satellite control reference platform is used to indicate the magnitude and direction of the orbital velocity vector.

For orbital maneuvering, the re-entry vehicle is powered by four fluorine-hydrazine rocket engines with a maximum thrust of 20 lb each. The engines are throttlable and self-igniting and have replaceable propellant tanks. Two of them are located aft on the sides of the turbojet and have a limited swiveling allowance. The other two, located amidships, can rotate

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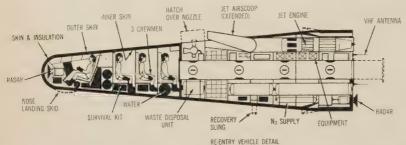


FIGURE 1: Re-entry vehicle is 37.5 ft long, 9.5 ft high, and 23.5 ft in diameter. Its weights are: ascent, 19,600 lb; re-entry, 16,485 lb; empty, 14,275 lb. The skin and insulation of the nose hinge back for visibility in orbit and are jettisoned for visibility in subsonic flight.

through a large angle to help in maneuvering.

Two solid propellant retro-rockets with a total thrust
of 18,000 lb and a hurning time of 20 seconds are

of 18,000 lb and a burning time of 20 seconds are used to start re-entry. At burnout, they provide a velocity decrement of about 800 fps.

The "astrotug" consists of two double-walled cylindrical pressure vessels joined by a cylindrical center section. Fully loaded, it weighs about 20,000 lb. The propellant tanks are arranged around the outside of the center section. At 90-deg intervals around the exact center of the vehicle, four swiveling rocket nozzles are mounted. During launch, the nozzles are retracted; in orbit, they are extended so that the hot flames will clear the structure.

Four mechanical manipulator arms extend from the front of the vehicle. These are jointed, motordriven, and controlled from the forward compartment. Each manipulator has interchangable "hands" designed for specialized jobs such as gripping, hammering, cutting, running screws or nuts, etc. The "hands" can be changed by remote control from inside the vehicle.

There's an emergency escape hatch. At the forward end of the vehicle, at the rear end is an air lock for transferring the crew from the tug to the space station or the re-entry vehicle. The crew moves between the compartments of the tug through an air-lock tube in the center section. A toilet in the rear compartment operates under zero-gravity by suction and centrifugal separation. Waste is propelled into the centrifugal chamber, slurried with water, and pumped into a storage tank for later disposal.

Pilot and copilot face outward from the tug; the navigator faces the center section. This control station contains a radar and infrared viewing console, a navi-

gation display and instrument panels, and controls for all communications and telemetry equipment.

The main controls and instruments are duplicated in each compartment as are the radar, radio, infrared, and navigation consoles, and the controls for the environmental units. The manipulator controls, however, are not duplicated—they appear only in the copilot's position in the forward compartment.

Manipulator control by scale models

This set of controls consists of an exact scale model of the external manipulator arms. Any manual movement of the model arms is repeated exactly by the manipulators. In practice, the operator also has a scale model of the item being manipulated for coarse alignments. Fine corrections are made by visual observation through the viewing port.

Typical aircraft practice is followed in the construction of the astrotug. The only notable difference is that the pressure vessel compartments are welded to make them gas-tight. The propellant tanks are made of stainless; the pressure tanks of fiberglass.

Levitated plastic insulation is foamed in place between the inner and outer vessels. It holds down the leak rate in case of a meteorite puncture and also provides thermal and sound insulation. A layer of soft Latex rubber is painted onto the insides of both inner and outer walls. It acts much as does the membrane inside a self-sealing fuel tank.

The astrotug's propulsion system consists of four pressure-fed low thrust rockets using fluorine and hydrazine. This combination was selected for its good bulk density, high specific impulse, and hypergolicity. A mass flow regulator is used for throttling.

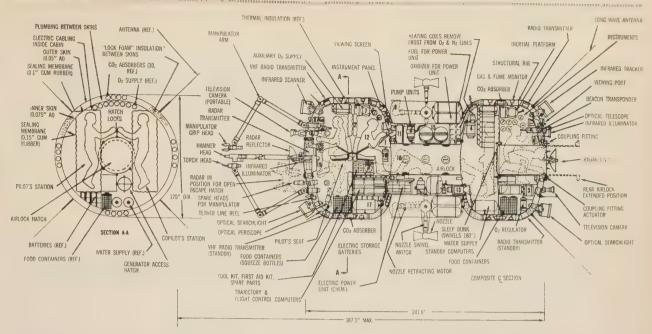


FIGURE 2: "Astrotug" detail—(1) navigator's console, (2) reclinable 180-deg-swivel seats, (3) telemetry unit, (4) air conditioning unit, (5) main 0_2 supply for breathing, (6) position of retracted nozzle, (7) inertial platform, (8) forward viewing port, (9) manipulator control

unit, (10) access hole cover, (11) instrument junction box, (12) navigator's station, (13) waste disposal unit, (14) optical telescope, (15) N_2 tanks, (16) O_2 regulator, (17) water supply, (18) hand-driven electric standby generator, (19) inner hatch cover.

Re-Entry Vehicle Weight (Ib)		Astrotug Weight (lb)	
Wing group	2,040 250	External surfaces	1,700
Stabilizer surfaces		Internal structure	1,550
Body group	4,025	Miscellaneous structure	505
Structure	6,315	Total structure	3,755
Jet engine (dry)	525	4 rocket engines (dry, thrust chambers)	28
Propellant systems IP-4	95	Fuel system	1,462
Fluor-hydrazine	500	Pressurization	120
Pressurization system	120	1 1655ut12ation	120
Guidance & control	2,736 1,237	Total propulsion system	1,610
Power supply	1,237	Communications	625
Communications	545 1,952	Guidance & control	1,370
Crew provisions Crew compartment cooling	250	Crew provisions	1,500
Crew compartment cooms		Auxiliary power	1,965
Total empty weight	14,275 1,405	Coupling & search equipment	1,900
Rocket fuel	329	Total empty weight	12,725
Rocket oxidizer	671 2,000	Fuel	4.570
Retro-rockets Crew	680	Oxidizer	1,930
Space & G-suits	85	Crew	510
Water supply	80	Water	140
Food supply	75 ———	Food	125
Total useful load	5,325	Total useful load	7.275
Total gross weight	19,600	Total weight	20.000
Total burnout weight in space Total burnout weight in atmosphere	16,485 15.080	total weight	20,000

Enough propellant is carried for a total non-continuous burning time of 5000 seconds at a total thrust level of 600 lbs. An emergency supply provides a thrust of 800 lb for 300 seconds.

The electric power supply system for the astrotug consists of a 28-V dc prime energy source of 350 kw-hr capacity, a 28-V dc nickel-cadmium secondary

battery of 300 amp-hr capacity, a voltage booster and regulator, a negative 28-V dc power supply, and 3200-cps, 115-V, single-phase and 400-cps, 115-V, three-phase ac inverters.

A high energy hydrogen-oxygen fuel cell is used as the prime energy source. Potential conversion efficiency is 60-70 per cent.—End

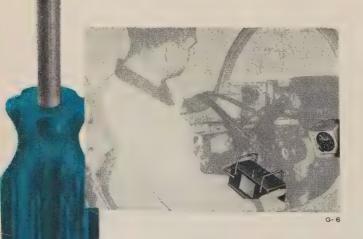
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Now only 1 man—instead of 3—trims fuel controls of all jet engines...faster...with greater accuracy... without hazard...all by remote control!

Eliminates exposure to dangerous noise and heat when trimming at the engine.

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EXCLUSIVE

HOW IT WORKS

In a matter of seconds, a servoadapter combination is clamped directly to the fuel control on the engine to be adjusted. This servoadapter is attached to a remote controller (usually in the cockpit) by means of an electrical cable. Thus one man can make all idle, military power and water injection adjustments.

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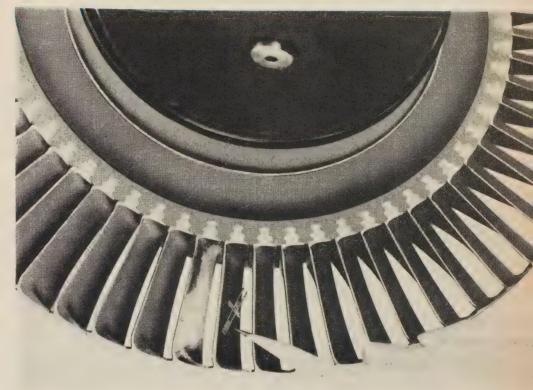


FIGURE 1: Typical strain gage installation for vibration tests is shown on a Lycoming T53 turbine blade. The adjacent blade already has a gage completely installed.

Strain gages

for higher temperature measurements

The need for high speed, high temperature testing has forced strain gage designers to push on to new limits of miniaturization and reliability. Here is a review of the latest developments in this field and of the new applications they have made possible.

by Paul Beckman and
Herbert Yanowitz, President and
Chief Engineer, High Temperature Instruments Corp.¹

₩rite in No. 25 on Reader Service Card

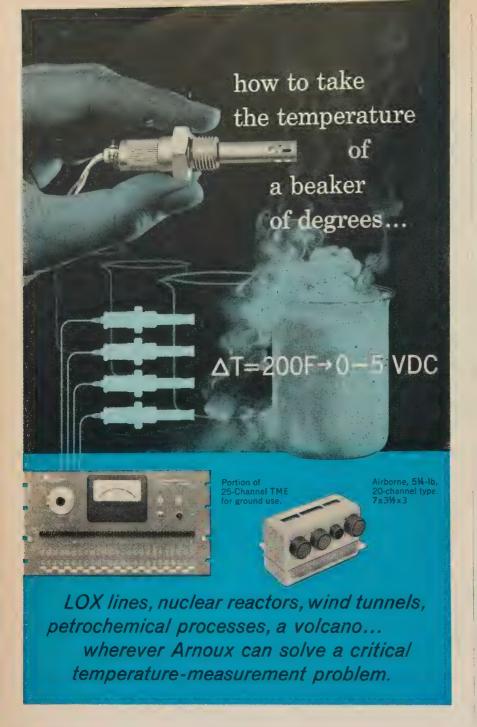
STRAIN is one of the most basic measurement values in the analysis of any structure. In most cases, strain measurements are made with bonded, variable-resistance wire gages. These have been in use for many years, and their room-temperature properties are well known.

However, at the increasingly high test temperatures that we run into today, changes occur in strain gage behavior that pose tricky new problems for the test engineer. The most important of these changes are:

- The electric resistance of the gage wire changes.
- The wire, the structure, and the bonding cement undergo thermal expansion.
 - The electric insulating value of the cement changes.

(1) High Temperature Instruments Corp., P.O. Box 378, Bala-Cynwyd, Pa.

more on next page



Solutions to temperature-measurement problems are not so elusive once an Arnoux high-level-output temperature-measurement system (TME) is installed. The multichannel, solid-state TME, a complete package, is versatile in application, flexible in use. TME features range selection, expandable temperature span, recalibration in seconds...direct high-level-voltage readout...dc amplifiers are completely unnecessary; result: low, low cost per channel...total range from -320F to +1000F...available in airborne or ground versions. ARNOUX CORPORATION

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TEMPERATURE-MEASUREMENT SYSTEMS

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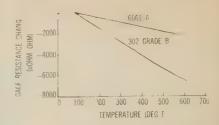


FIGURE 2: Apparent strain curves for HT-600 strain gages bonded with Allen PBX ceramic cement to 302 Grade B low carbon steel and 6061 aluminum.

• The strain sensitivity of the wire changes.

• The gage and the structure oxidize and corrode more readily.

• Organic cements begin to lose their strength and decompose.

The high temperature region for strain gages may be said to begin when organic bonding cement must be replaced by ceramic types. In this region, the best gage performance has been attained in vibratory tests. In these, all resistance changes not caused by vibratory strains are filtered out electronically. Naturally it is still necessary to know the overall gage resistances and the gage factor at the temperature of operation.

Figure 1 shows a typical application of strain gages in vibratory tests-H-T high temperature gages are installed on the turbine blades of a Lycoming T53 jet engine for dynamic strain measurement. The gages proved highly reliable at speeds up to 25,000 rpm, which imposed centrifugal loads as high as 100,000 Gs on the gage installation.

To withstand gas temperatures up to 1200 deg F, the gages had Karma² wire grids swaged to flat, burnished nickel leads. At even higher temperatures, Nichrome V2 wire and leads were used.

The gages used in this T53 installation met all the basic design requirements for high temperature turbine blade strain measurement:

· The gages were made of heatresistant materials, could use flat leads, and had no spot-welded connections.

• The gages were designed to make flat installations easy.

• The gage wire had a high specific resistivity, so that small

(2) Registered trademarks, Driver Harris

for the conquest of space



"MISSION ACCOMPLISHED: DEPARTING LUNA 2205 ZEBRA"

This message, flashed across a quarter-million miles to Washington, D.C., will be awaited anxiously by millions.

But even then our first expedition to the moon will still face its most crucial test—the journey home to earth.

The success of that trip will depend in large part on rocket propellants fuels and oxidizers that will have been stored for days in the tanks of the expeditionary vehicle and yet will respond instantly when needed.

Storable liquid propellants is one of the fields in which Rocketdyne has anticipated the future. For more than ten years, its propellant chemists have been studying, engineering, and testing combinations of storable fuels and oxidizers for greater storability and higher energy.

Storability PLUS high energy

Rocketdyne has tested these combina-

tions in all production and experimental engines. The results prove that today's storable fuels and oxidizers have these important capabilities:

(1) High performance, even after months or years of storage; (2) Stability over a wide temperature range, permitting storage in missile tanks without rigid environmental controls; (3) Dependable performance, predictable even at extremes of heat and cold; (4) Instant readiness for firing at any time during the storage period; (5) Energy yields equal to or higher than those of conventional propellant combinations.

Second-generation missiles

The tests also prove that engines developed for conventional propellants can be converted to storable combinations rapidly and inexpensively—a significant consideration in the devel-

opment of second and third generation strategic, tactical, and air defense missiles.

Significant, too, is the *potential* performance of storable combinations. Research points to energy yields as high as 400 seconds of altitude specific impulse—performance 20 percent higher than that of today's combinations. These high-energy yields will offer new capabilities and greater flexibility for America's scientific and military programs.

Stepping stones to Space

Rocketdyne has designed and built much of today's operating hardware in the high-thrust rocket field. Engines by Rocketdyne power most of the military and scientific projects



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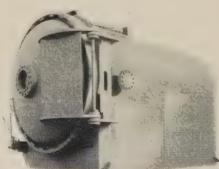
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FH-64 EXPLOSION-RESISTANT CHAMBER. One of 50 Conrad chambers at Hughes. Temperatures ambient to $+800^\circ F$., altitude ambient to 100,000 ft Proof tested at 300 lb. p.s.i. Interior shell 68'' dia., 72'' long.



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STRAIN GAGES . . .

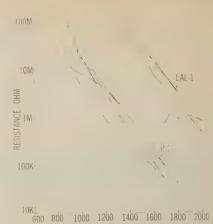


FIGURE 3: Resistance to ground of HT-1200 strain gages bonded to Inconel with Allen P-1 and LAL-1 ceramic cements in two heating cycles.

TEMPERATURE (DEG F)

gage sizes could be produced at standard resistance values. (Present gage resistances and dimensions are 120 ohms and $\frac{3}{2} \times \frac{1}{8}$ in., 500 ohms and $\frac{3}{2} \times \frac{5}{16}$ in., 1000 ohms and 3/16×1/4 in., and 2000 ohms and $\frac{3}{8} \times \frac{1}{4}$ in.)

For static strain measurements, more information about the gage is needed than for dynamic measurements. To begin with, we need an "apparent strain" curve. This curve, which varies for different values of thermal expansion, plots the relationship between the change in resistance, or "apparent strain" and the operational temperature of the strain gage.

Figure 2 shows the apparent strain curves of the HT-600 gage for two metals. If such a curve is repeatable—as it is for the HT-600 to 600 deg F-it can be used to correct strain readings at any given temperature. The temperature of a strain gage installation at the plane of the grid can be measured accurately and conveniently if the gage has an integral thermocouple.

The drift rate of the gage also must be known for static strain measurements. Drift is the change in the resistance of a strain gage that is not caused by temperature or load changes. It can be virtually eliminated, as in the HT-600 gage for temperatures up to 600 deg F. Above that, this gage will drift, but the drift will disappear again if the gage is cooled to less than 600

For tests at a constant temperature above 600 deg F, a gage such

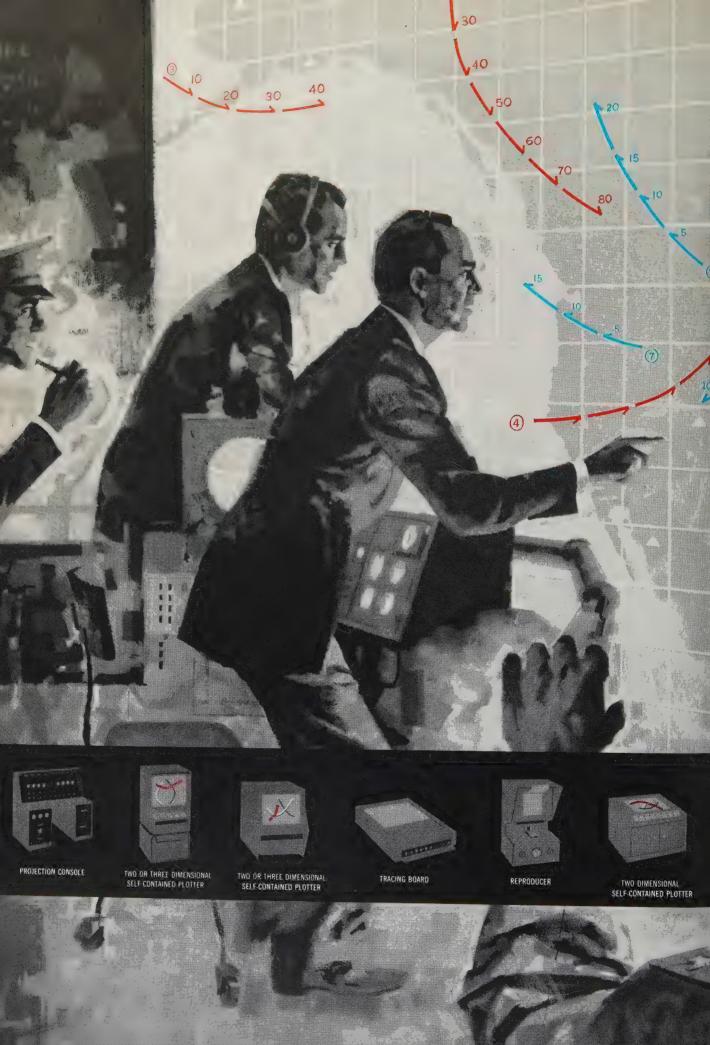
more on page 72



Bomarc reception committee for the enemy intruder

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RELAYS

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Fast action with freedom from bounce, plus high sensitivity and consistent operation with low distortion, are provided by small, rugged Series P Polarized Relays. SPDT, with two independent coils, they will handle over 1,000 pulses per second. Various coil resistances up to 5,000 ohms each coil. Contact ratings vary with switching speed but range from 60 MA to 2A with voltages to 120 AC or DC, dependent upon amperages employed.



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Miniature, hermetically sealed 4PDT, Series R & S relays provide excellent reliability over their long service life. Electrically and physically interchangeable, the two series differ only in that Series S coils are separately sealed within the sealed cases, with organic matter eliminated from the switch mechanism for greatest reliability in dry circuits. Contacts MA to 10 A.



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Series R/S Relays are available with 10 standard mounting arrangements, plus a ceramic plug-in socket. MS-AN type connector mounting, illustrated at right, makes assembly, installation and field service extremely simple, while the connector provides a seal against moisture.



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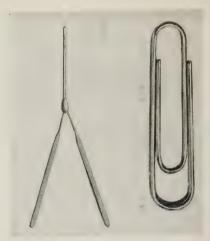


FIGURE 4: Recently introduced mono-filament strain gage is made with a ceramic coating over the active element.

Physical Characteristics of Allen Ceramic Cements

	P-1	PBX
Cross-bending strength At 300 deg C	(psi) 900	2565
At 600 deg C	1100	3360
Shear strength (psi, measured on Stellite 25 with specimen		
sand-blasted)		390

as the HT-1200 is recommended, which is made from a very stable, platinum-based alloy. The platinum gives the gage a high gage factor but also a high coefficient of temperature resistance.

For both dynamic and static strain measurements, the electric resistance of the bonding cement is highly important. If this resistance is low, there will be a shunt. distributed partly through the test member and partly through the gage installation. This shunt depends on the thickness of the installation and is very apt to be erratic. A cement with low electric resistance will also lead to spurious signals in the electric circuitry.

For many years, the standard strain gage cements have been the Allen P-1 and PBX ceramic types³ (see Table). Several new Allen cements are under evaluation, and one of these, LAL-1, should soon be commercially available (Fig. 3). One of the major troubles with

(3) Distributed by High Temperature Instruments.

more on page 74



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Flight's historic limitations are being overcome. Today's speeds, distances, and altitudes will soon be extended even beyond the frontiers that research is just now reaching.

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In the area of nuclear propulsion, for example, Pratt &

Whitney Aircraft has demonstrated important technical achievements which only a year ago were considered impossible or highly improbable. Major accomplishments have also been made in high-energy liquid propellant rocket engines, and other advanced applications of power for flight. These advances are opening the way for ultra-long-range aircraft, as well as for vehicles of space travel.

Flight Propulsion by PRATT & WHITNEY AIRCRAFT

East Hartford, Connecticut A division of United Aircraft Corporation





Skin-mounted RMC-Lindsay pressure gauges give Crusader quick, accurate ground check...

The Chance Vought Crusader's pneumatic systems are ground checked with a glance at the RMC-Lindsay High Pressure Gauges installed in the outside skin of the plane.

3,000 supersonic miles—and a transcontinental record later, they will still be registering accurately . . . as they will for the life of the plane.

Two of the gauges are of the suppressed zero type, registering from 1,000 to 4,000 p.s.i. The other registers from 0 to 4,000 p.s.i.

These gauges have undergone a 50G shock test with no ill effects. They will withstand vibration from 10 cps. to 2,000 cps. at 25Gs, at ambient temperatures from -65°F to +350°F. They are moisture sealed at the crystal.

There is no linkage, no gear train to disintegrate or to cause pointer vibration. The indicating pointer is attached directly to the end of the helical bourdon tube.



MODEL #6903 (Actual Size)

RMC-Lindsay High Pressure Gauges have proved themselves—in performance—on record-setting transcontinental jet flights, on innumerable take-offs and landings, on missile guidance systems, and on missile test stand countdowns.

Whatever your high pressure gauge problems may be, why not let RMC engineering skill provide the answers. Write, wire or phone either of the addresses below.

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ROCHESTER MANUFACTURING CO., INC. 224 Rockwood St., Rochester 10, N. Y.

LINDSAY PRESSURE GAUGES



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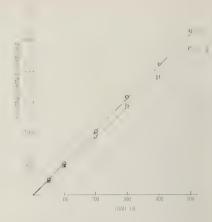


FIGURE 5: Performance of monofilament strain insert in an AN4C7a stainless steel bolt.

ceramic strain gage cements is that they are hydroscopic. If the strain gage installation is cooled to room temperature, it therefore will pick up moisture and may give false readings.

A line of sealants is being developed to eliminate this defect. SD, the first of these sealants, fires at 700 deg F and forms a glassy coating over the strain gage installation. During subsequent heating cycles it remains impervious to gas and moisture and retains its high electric resistivity up to 900 deg F. For higher temperatures, a sealant that fires at 1450 deg F has been developed, and sealants for the intermediate range should soon become available, too.

Another recent development is the "monofilament" strain gage (Fig. 4). It is 0.012 in. in diameter, ½-½ in. long, and available in 60-and 120-ohm sizes in all standard gage materials. A ceramic cement coating covers the active element of this strain gage, which therefore can be used on specimens that have not been precoated and even with cements that do not have the electric resistivity of the normal strain gage cements. The gage can also be heat-treated and calibrated before use.

The mono-filament gage originally was developed for insertion in the axis of an aircraft bolt, where it was to measure the in-flight loads on a structural member (Fig. 5). For this application, the gage was made from Karma wire and had a ceramic body serving as a pilot. Circle No. 67 on Reader Service Card for more data.—End

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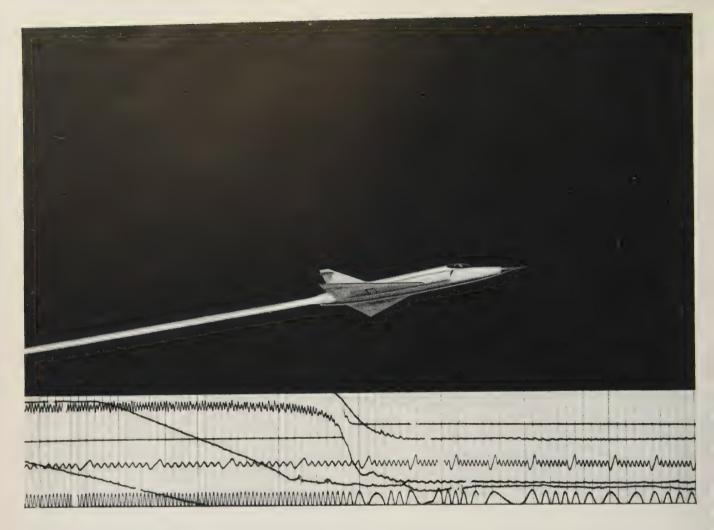
Do these Springfield "400" applications suggest anything to you?

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These three papers are available in two types: Type B, standard-weight stock when greater opacity is required, and Type W, a thin, 100% all-rag stock.

Lino-Writ 4. It's the toughest, fastest, whitest paper you can use; 20% thinner than Type W, accommodates writing speeds as high as 5000 cps at maximum amplitude. Exceptional exposing and processing latitude. All-rag stock has unusual wet or dry strength.

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Better Things for Better Living . . . through Chemistry



New Mace missile with fold-back wings.

Found: missile engineering that combines extreme accuracy with lower cost machining

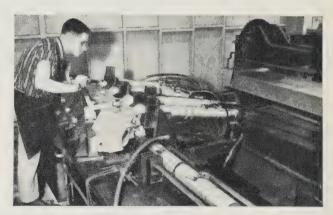
PROJECT—New Mace missile with fold-back wings. Chief advantages of the folding wings: easier transportation . . . permit use of launching sites hitherto inaccessible.

TARGET—To design fold-back wings that combine extreme accuracy with lower cost machining.

PROBLEMS—Centered around fittings that hinge the wings to the missile body. Ordinarily, each fitting would be forged as a single piece and painstakingly contoured—an operation requiring much handwork.

SOLUTION—Each fitting was forged in two sections, with emphasis on contouring. Then the mating surfaces were slab-milled to the required thicknesses. One Gardner-Denver "Airfeedrill" fixture drilled eight ¾" bolt holes for joining the halves, while another drilled splice and hinge-attaching holes.

This is just one graphic example of the versatility of Gardner-Denver "Airfeedrills." From missiles to micro switches, they cut production drilling time and costs.



Gardner-Denver "Airfeedrill" fixture machines holes that join right- and left-wing panels of Mace missile. Consult your Gardner-Denver representative for complete information. Write for Bulletin 92-1.



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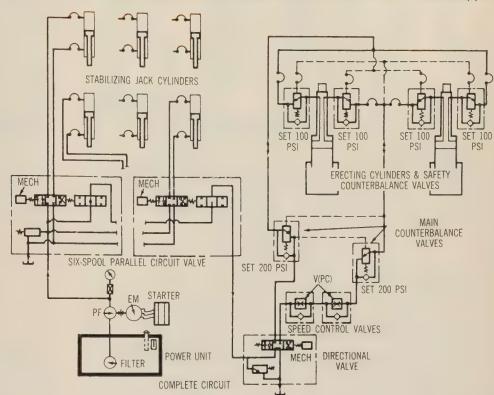


FIGURE 1: Complete circuit for the main erecting cylinders, the power unit, and the stabilizing jack cylinders.

Hydraulics packs power for

missile erection

For precisely controlled missile erection, hydraulic power is best. Here is a report on the erector hydraulics used in Polaris tests, which gives you an idea of the general design that would apply to other big missiles, too.

A MOBILE erector for large missiles such as Atlas, Polaris, or Titan requires a much more complex hydraulic system than does a fixed installation. Weight is always a problem with mobile equipment but envelope limitations are even more critical.

The main cylinder envelope especially deserves attention during the early design stages. Any mistake here in mechanical design invariably leads to poor system performance and costly modifications.

The three most important performance factors for a mobile erector are:

*The Rucker Company, 4700 San Pablo Ave., Oakland 8, Calif.

more on next page

by G. Duane Shaw, Senior Project Engineer, The Rucker Co.*

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BOLTS, HUCKBOLTS, OS AND DAISY RIVETS.

*Trademark Huck Manufacturing Co.

The Huck "200" is a sturdy, light weight (10 pounds) tool which will install up to thirty fasteners per minute in unskilled hands. Its construction is simple and husky, developing 3000 pounds pull at 90 p.s.i. air line pressure. Because it has so few moving parts, wear and maintenance service is minimized.

Single action adjustment to various fastener sizes is automatic-quick change, preset cartridges adjust for double action use with no further adjustments necessary.

The "200" uses standard nose assemblies.

(Also available in kit form for maintenance service).



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MANUFACTURING COMPANY

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FIGURE 2: Emplaced erector used in Polaris tests. The telescopic twin main cylinder system raises the missile from its horizontal transport position to the erect launch posi-

 Variable-Speed Control -Within a few seconds and usually at rather high velocities, the missile must be accelerated and then decelerated smoothly from one fixed position to another.

• Precise Positioning—Regardless of variations in missile weight or wind loadings, the erecting arm must travel an exact distance in response to manual or automatic

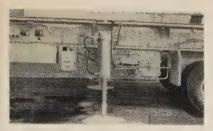
input control signals.

• Low G-Load Programing— Throughout the erection or lowering cycle, speed variations must be closely limited to keep from overloading the missile's structure or any of the equipment it carries. Some missile structures are designed to take high G-loads in flight but are very easily punctured, crushed, or otherwise distorted while on the ground. This danger is particularly high with some pressurized thin-skin sections.

G-loads very critical on test missiles

Test vehicles esspecially have very critical G-load limitations. The Polaris test erector, for example, is designed so that the loadings will never go over 11/2 G. Speed control can be varied both manually and automatically.

The Polaris test erector (Fig. 2) was designed to transport missiles to the field launching area and erect them for firing. Six stabilizing cylinders, or jacks, that are collectively or individually oper-



CONTROL and stabilizing section of the Polaris erector.

ated and two main telescopic cylinders are its hydraulic actuators.

Hydraulic system weight was kept down as much as possible. However, cost, not weight, was the main consideration. Special components were used to avoid extreme weight penalties. The hydraulic power package, for instance, consists of a 75-gal oil reservoir, a 15-hp, 1200-rpm electric motor, and a gear-type pump. It can deliver up to 14 gpm at 1250 psi maximum.

Figure 1 shows the complete hydraulic circuit for the Polaris erector, including the directional and flow control system for the main cylinders. The control valves for the six stabilizing jack cylinders are in a single housing.

Main cylinders' ram stages start erection

Missile erection from the horizontal travel position starts with the first, or "ram," stage of each main cylinder. This first stage has an 8½-in. diameter and an 85-in. stroke. At the point of first movement, the twin cylinders operate with an effective lever arm of about 99 in. Taken about the pivot pin or the erecting arm, this lever arm produces a torque of about 1,170,000 ft-lb.

As the first stage comes to the end of its full stroke, the double acting second stage takes over. The erection side of this stage has a 7½-in. diameter and a 70-in. stroke that is mechanically limited to 57½ in. When it starts, the second stage produces a torque of about 900,000 ft-lb at the end of a 97½ in. lever arm.

For Polaris, the peak cylinder requirement for erection occurs just when the second stage starts to move. As the erector arm approaches the vertical position, the

more on next page



load passes over center, so the second stage must restrain it from running away.

Going from the vertical to the horizontal, the cylinder must exert a pull until the load passes back over center and tends to return by gravity. The lowering side of the second stage has a five-inch diameter. At the point of first movement from the fully erected position, it produces a torque of about 314,000 ft-lb at the end of a

61½-in. lever arm. By the time the second stage is fully retracted and movement starts on the first stage, the load is well past center and the arm (empty or loaded) returns to its horizontal position by gravity.

Safety counterbalance valves protect against cylinder runaway by restricting the flow of oil out of the cylinder during both erection and lowering cycles. In the event of a runaway, the pressure on the

inlet side of the valve drops off, tending to close the outlet and slow the speed back to normal. These safety valves normally will never be used for counterbalance except in an emergency—if the main counterbalance valves fail to operate or a hydraulic hose or tube line breaks.

The main counterbalance valves must open and close gradually rather than sharply while metering the oil flow. Standard industrial and aircraft-type valves fall down in this respect.

Missile erectors impose quite abnormal design requirements. Most cylinders have an extremely short effective lever arm with respect to the pivot point of the arm. Minute variations in cylinder travel, imperceptible to the naked eye, can produce disastrous variations at the tips of the arm or of the missile.

Because of weight limitations—especially on mobile erectors—the erector arm does not have much structural rigidity. Often it will deflect appreciably under relatively low speed variations. So it can very easily turn into a spring-mass system ready to amplify any minute speed variation at the cylinder rod to such an extent that the erection or lowering cycle must be stopped to prevent damage.

Abrupt control is common valve defect

The shortcomings of industrial and aircraft-type valves lie in the fact that their control is too abrupt. The valve spool moves from full open to full close too quickly or else there is not enough linear spool travel to provide the necessary control.

For the Polaris erector, the main counterbalance valves were specially designed to overcome these drawbacks. Their two outstanding features are:

• A special spool is designed to travel a long distance linearly between full closed and open positions. It also does not have the usual taper of standard counterbalance valve spools. Instead, it is hollow. The oil flow is metered by a series of small holes drilled through the center passage. With a spiral pattern and proper hole spacing, it is possible to develop a straight line variation in the area available for oil flow as related to spool displacement.

more on page 82



time ... In the deadly game of chance we call the cold war, there's no room for guesswork. We must know, every hour of every day, exactly where our potential enemies' strength lies.

Electronic Reconnaissance today is one of our major defensive weapons—incredible "eyes" with which we can not only detect enemy radar and missile guidance signals, but determine with precise accuracy the location, type and capability of the signal source as well.

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A unique combination of engineering and scientific skills, coupled with production ability... plus more than two decades of continuous development and production of newer and better airborne instruments – over 400,000 reliable guidance controls delivered – these are the reasons why Whittaker Gyro instruments are operational on many of the nation's major missile programs. From a simple gyro to complete stabilizing systems... Whittaker can provide the latest in design.

actual size

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- reliable performance from
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NEW MALTESE CROSS <u>TEFLON</u> HOSE WITHSTANDS OXIDIZERS AND ROCKET FUELS

Almost every aviation use is covered with this amazing new Hewitt-Robins TEFLON*-lined hose. It is ideally suited for fueling all kinds of rockets, missiles, and advanced aircraft . . . and because of its anti-hesiveness, it is easily and thoroughly cleaned for other uses. Its flexibility permits use on reels for compact ground support applications.

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COVER of tough, abrasion resistant neoprene.

CARCASS of steel wire braid for strength

and flexibility.

TUBE with high quality TEFLON lining.

Write today to Hewitt-Robins, Stamford, Connecticut, and ask for Bulletin 8-23-S-603.

AVAILABLE IN SOME SIZES IN LENGTHS UP TO 50 FEET

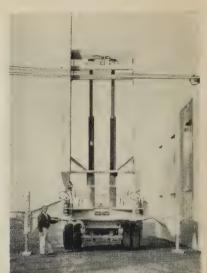
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REAR STABILIZING cylinders swing out from the frame structure to steady the missile and keep it from toppling sideways.

• Spool shift—and thus linear velocity—is carefully controlled through a throttling orifice and a pilot control head to improve the metering characteristics. Speed can be varied over a considerable range to adjust spool travel from relatively rapid to extremely slow traverse. In combination with the drilled holes, this feature provides excellent damping control.

The single-acting first-stage cylinders limit the choice of speed control in a system using valves and a fixed-delivery pump. For the Polaris system, a "meter-in" control is used for erection and a "meter-out" control for lowering. This arrangement allows speed control throughout the full arc in both directions. It also offers certain advantages for the mechanical design of the program control.

Variable pressure-compensated flow control valves in parallel with bypass check valves provide automatic and manual control. Acting on a mechanical signal from the erector arm, a cam program control limits the maximum speed at any given point in the cycle.

Manual control is possible at all points in the erection arc. Since the maximum speed is limited by the program cam, the operator can never accidentally overspeed the system. Acceleration and deceleration at the extreme ends of the cycle are also controlled by the program cam. Circle No. 64 on Reader Service Card for more information.—End



At every stage, the success of a missile program depends upon a computer. Librascope computers, components, instruments and systems give right answers from original concept to final evaluation.

THE FIRST STAGE: Workable designs. SECOND STAGE: Trajectory and engineering computations required long before the launching. THIRD STAGE: Control, guidance; impact prediction. FOURTH STAGE: Data reduction and analysis. Recognizing still a fifth stage, Librascope determines reliability in the lab. Environmental tests check equipment for temperature, shock, vibration, pressure and other "real" conditions likely to affect performance. Only positive answers will release Librascope equipment for field use.



For information on career opportunities at Librascope, write Glen Seltzer, Employment Manager.

Librascope's technical ability to meet exacting requirements has ably served our many military customers in the development of missile programs.

For further information on Librascope's computer capabilities for missiles write:



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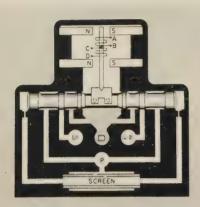
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Write in No. 39 on Reader Service Card at start of Product Preview Section



KEARFOTT ELECTROHYDRAULIC SERVO VALVE

obsoletes flapper-nozzie designs



Simplified schematic shows operation: fluid from input port passes through screen and fixed orifices to chambers at ends of spool. Passages in spool lead to two variable orifices at either side of center. Varying current in either torquemotor winding displaces armature; resulting differential pressure repositions spool. This establishes new equilibrium among pressures in load ports L1 and L2; drain port D, and supply. Slide fork closes the variable orifices at null.



Kearfott's unique approach to the design of electro-hydraulic feedback amplification has resulted in reliable, high-performance miniature servo valves with just two moving parts. Ideally suited to missile, aircraft and industrial applications, these 2-stage, 4-way selector valves provide high frequency response and extreme reliability without the need for mechanical null adjustments. This reliability has been tested and proved not only by Kearfott but by a number of firms prominent in the missile field.

Anti-Clogging Design

Large orifices prevent clogging and silting and high shear forces permit efficient operation even with highly contam-inated fluids. Positional feedback substantially reduces flow force reactions while hydraulic centering of pilot position eliminates the effects of hysteresis and null shift. Even under extreme temperature variations, Kearfott's unique valves consistently function at optimum efficiency.

Kearfott servo valves provide full motor power since the high ratio of available force to friction makes possible a lower threshold, reducing dead band and minimizing force

required for centering motor. They are available in a variety of types, including #6103 with a flow rate of .3 to 4 gpm and #6104 with a flow rate of .8 to 10 gpm.

Typical Characteristics

Supply pressure...500 to 3000 psi Temperature-Fluid & Ambient......-65°F to +275°F Quiescent Flow.. ...0.15 gpm Hysteresis.....3% of rated current Deadband......1% of rated current (Minimum current to establish flow)

DESIGNS AVAILABLE WITH FREQUENCY RESPONSE OUT TO 250 CPS

Hydraulic actuator subsystems can be supplied as follows:

- Linear or rotary actuators with or without positional feedback and power supply.
- · Servo valve-actuators. Feedback can be provided consisting of voltage or resistance devices.
- Actuators whose bodies contain first and second stages of the servo valve with torque motor mounted on common actuator-valve body. Feedback devices can be supplied integral with actuator or mounted externally.

Write for complete information on Kearfott valves today.

KEARFOTT COMPANY, INC., LITTLE FALLS, N. J.

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Sales and Engineering Offices: 1500 Main Avenue, Clifton, N. J.
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Engineers: Kearfott offers challenging opportunities in advanced component and system development.



GENERAL PRECISION COMPANY

GPL systems management

equipment for the Federal Aviation Agency

data processing central-the heart of tomorrow's air traffic control system-point up the diverse talents required of an effective systems manager. As prime contractor for this FAA Bureau of

Research and Development project, GPL contributes to the design and assumes responsibility for direction, schedules, plans, budgets, and the performances of nine associated companies. Necessary technical capabilities include broad knowledge of air traffic control problems, computers, data handling, radar, communications, human engineering, and "systems thinking" capable of integrating these varied disciplines into a practical, workable system.

GPL's contracts for the FAA's experimental

The FAA data processing central is but one of a number of current airborne and ground-based programs reflecting GPL's capabilities as systems manager. Supporting these programs are a "systems" oriented technical organization, a "customer" oriented management, and a complete capability from research, engineering, and manufacturing on through to customer service.

The systems management skills of GPL are available to you. Write for further details on the application of these skills to your problem.

GPL Avionic Division/airborne navigators/missile guidance/ radar/airborne computers/data handling systems/ communications equipment/infra-red/closed-circuit TV.



ENGINEERS — GPL achievements have opened a number of challenging research and development opportunities. To be considered for these career positions, send resume of previous experience to Personnel Director.





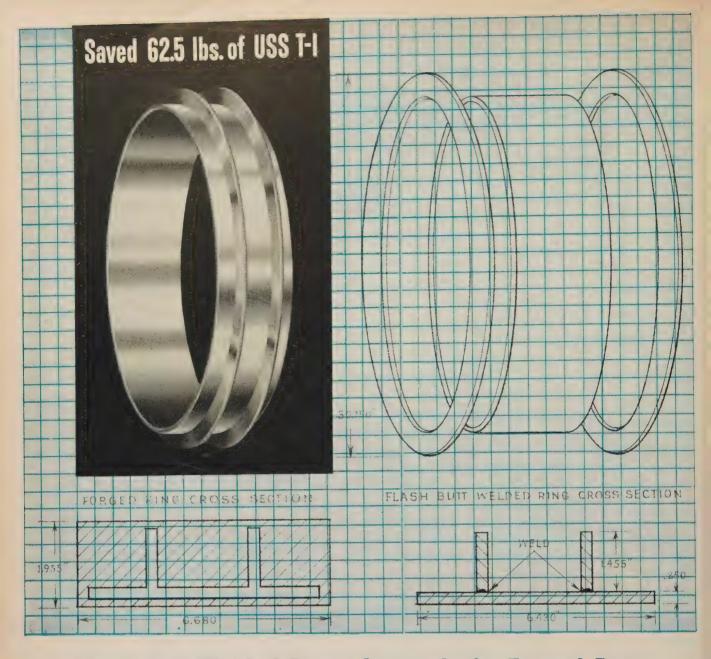




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RESEARCH / FLIGHT TESTING / ENVIRONMENTAL TESTING

GENERAL PRECISION LABORATORY INCORPORATED, Pleasantville, N. Y. A Subsidiary of General Precision Equipment Corporation



Flash Butt-Welded Rings Instead of a Forged Part SLASHED \$50.43 on Sway Brace Ring

By circumferentially welding two flash butt-welded rings around a flash butt-welded band, Amweld engineers eliminated a bulky forged ring and hours of machining. The finished part, a sway brace ring for a jet engine, met manufacturer's critical requirements for aircraft use.

Savings like these have been effected on a wide variety of aircraft and missile parts, particularly where high-strength, high-temperature alloys were involved.

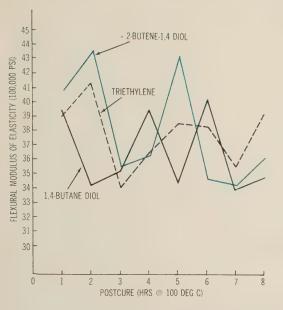
Amweld's 41 years of fabricating experience are backed by extensive welding, forming and machining facilities. We will be happy to study your problem and to handle subcontract work on either prototype work or production orders.



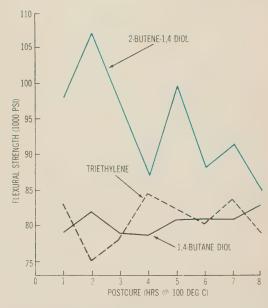
THE AMERICAN WELDING & MFG. CO. . 558 DIETZ ROAD . WARREN, OHIO



Materials



EFFECT of postcure time on flexural strength and moduli of elasticity of three polyurethane laminates. Glycols



with four-carbon chains look most promising. (See Table I for more data on these formulas.)

New polyurethane laminates

show good flexural strengths

Diisocyanate-based resins have been getting a lot of attention in plastics research. Here is a report on a test series that indicates that these resins hold great promise for improved plastic materials.

Argelo P. Bonnani, Project Engineer,
Aeronautical Materials Laboratory, Naval Air
Material Center.*

STUDIES at the Naval Air Material Center's Aeronautical Materials Lab have led to development of a promisingly simple, controllable method for formulating a polyurethane low pressure laminating resin. Preliminary investigation has shown that it's possible to use such a resin to make glass fabric laminates with strength properties exceeding those required by the specs covering polyester, epoxy, and phenolic laminating resins.

The formulating procedure results in resins with re-

more on next page

^{*} Naval Air Material Center, Philadelphia 12, Pa. The statements in this article are not to be construed as official or as reflecting the views of the Navy Dept. or the Naval Service at large. The author wishes to thank L. C. Ritter and other members of the Aeronautical Materials Lab for their help in his investigation.



Induction Motors of California Size 8 Synchro

Induction Motors of California Manufactures **Complete Synchro** Series

A full line of size 8 (.750" diam.) and size 11 (1.062" diam.) synchros, resolvers and linear tranformers for indication and control are manufactured by Induction Motors of California, Maywood, California, in general accordance with MIL-S-20708.

GENERAL SPECIFICATIONS
FOR TYPICAL SIZE 8 SYNCHROS

26 VAC 400 CPS

± 7' MAXIMUM ERROR 30 MV MAXIMUM NULL

IMC TYPE	INPUT (MA)	PHASE SHIFT (DEGREES)	OUTPUT (VOLTS)
Torque Transmitter 9708-002 008-235	150 100	12	11.8 11.8
Control Transformer 9708-003 9708-007 008-334	120 7 29	12 17 8	23.5 22.5 22.5
Resolver Transmitter 9708-004	50_	22	10.4
Linear Transformer 9708-005	110	10	18.0
Control Differential 9708-006 (Rotor Primary)	100	12	11.8

Detailed Specifications Available Upon Request

OVER 100 DESIGNS AVAILABLE

Induction Motors of California has over 50 standard Size 8 designs. Any of these may be furnished with electrical or mechanical variations to suit your particular application.

Over 50 standard Size 11 synchro designs, including Navy BuOrd types, have been produced to meet exact customer requirements. A typical group of 115V and 26V BuOrd synchros immediately available are:

11TX4b 11TR4b

Specifications on synchro components, as well as complete information on step-servo motors and solenoids manufactured by our company, are available when requested on company letterhead.

Induction Motors of California

DIVISION OF IMC MAGNETICS CORP., N.Y. 6060 Walker Avenue, Maywood, California LUdlow 3.4785 Representatives in principal cities

Write in No. 43 on Reader Service Card 88

NEW LAMINATES . . .

Table I: Test Data for Diisocyanate-Base Resin & Glass Fiber Laminates^A

		ininininininininininininininininininin				
Reacting Glycol	C Atoms	Viscosity 25° CB (cp)	Specific Gravity of Resin at 25° C°	Panel Density @ 25° C (gm/cm³) ^D	Laminating Press Time (min)	Laminate Thickness (In.)
Ethylene With 025% triethylamine catalyst	۷				120	
No catalyst	2				60 ^G	
Propyjene (no catalyst)	3				60	
2-Butene-0,4 diol (no catalyst)	4	75 .		1.996	25	0.092 ^H 0.093 ^I
	4	95		2.216	25	0.09211
	4	135	1.1092		25	0.100 J 0.097 ¹
1,4-Butane diol (no catalyst)	4	65	1.0796	1.992	25	0.089 ^{II}
	4	150	1.0928	1.945	25	0.092 ^I 0.092 ^I
Diethylene (no catalyst)	4			1.992	25	0.090H 0.090I
	4	25		2.027	25	0.093H
	4	125		2.008	25	0.109 ^I 0.087 ^H
Dipropylene (no catalyst)	6				120 60	0.086 ¹
Triethylene (No catalyst)	6	55 88	1.0778 1.0849	2.061	25 25	0.092 ^H 0.092 ^I 0.094 ^J
White or of the later is a	6				60	0.0949
With 0.25% triethylamine catalyst	6				120K 120	

	Flexural Strength (psi)F			Modulus of Elasticity ^F			
	No Post- cure	Post- cure @ 70° F	After 9 Hr in 100° C H ₂ O	No Post- cure	Post- cure @ 70° F	After 2 Hr in 100° C H ₂ O	
Ethylene With 0.25% triethylene catalyst	56,700	61,100	47,000	3.21×10 ⁻⁶	3.38×10 ⁻⁶	3.78×10 ⁻⁶	
No catalyst	46,600	46,900	49,700	1.62×10 ⁻⁶	2.40×10 ⁻⁶	2.41×10 ⁻⁶	
Propylene (no catalyst)	83,100	76,000	70,900	3.79×10 ⁻⁶	3.40×10 ⁻⁶	3.59×10 ⁻⁶	
2-Butene-1,4 diol (no catalyst)	90,080 88,800	99,9001	61,400 72,100 74,100	4.35×10 ⁻⁶ 3.92×10 ⁻⁶	3.67×10 ⁻⁶ J	4.64×10 ⁻⁶ 4.58×10 ⁻⁸ 4.31×10 ⁻⁶	
1,4-Butane diol (no catalyst)	92,800	85,500J	53,400 52,800	4.14×10 ⁻⁶	3.92×10 ^{−8} J	4.71×10 ⁻⁶ 3.98×10 ⁻⁶	
Diethylene (no catalyst)	83,000 82,000 100,200		35,900 32,100 71,800	4.52×10 ⁻⁶ 3.99×10 ⁻⁶ 4.17×10 ⁻⁶		2.52×10 ⁻⁸ 2.75×10 ⁻⁸ 4.05×10 ⁻⁸	
Dipropylene (no catalyst)	61,700 94,500	57,300 72,900	59,900 59,900	3.87×10 ⁻⁸ 4.18×10 ⁻⁸	3.28×10 ⁻⁶ 2.80×10 ⁻⁶	3.80x10 ⁻⁶ 3.20x10 ⁻⁶	
Triethylene No catalyst	47,400	73,500 J	delaminated 30.900	4.27×10 ⁻⁶	3.39x10 ⁻⁶ J	delaminated 3.45×10 ⁻⁸	
With 0.25% triethylamine	76,500	55,400	38,400	4.28×10 ⁻⁶	3.08×10 ⁻⁸	3.12×10 ⁻⁶	
catalyst	61,400 70,100	57,600 53,200	41,200 53,400	3.74×10 ⁻⁶ 3.02×10 ⁻⁶	3.27×10 ⁻⁶ 2.47×10 ⁻⁶	3.24×10 ⁻⁶ 2.64×10 ⁻⁶	
(A) Average of three profines (P) Mayord will D. 16 1116							

(A) Averages of three specimens. (B) Measured with Brookfield Viscometer. (C) Determined immediately after preparation with Gay-Lussac specific-gravity bottle. (D) Determined in accordance with Method 5011 of Fed. Spec L-P-406b. (E) Laminating load and temperature were 1100 lb and 300 deg F, respectively. (F) Determined in accordance with Method 1031.1 of Fed. Spec L-P-406b. (G) 350 deg F laminating temperature. (H) No postcure. (I) After immersion in boiling water. (J) Postcure at 100 deg C. (K) 340 deg F laminating temperature.

producible properties. It is based on the fine control of the reaction exotherm produced by the cleavage of the double bond between the nitrogen and carbon bonds of the diisocyanate radical. This cleavage is due to the migration of the proton (active hydrogen) from

the hydroxyl radical of glycol. An ice bath is used to retard the reaction rate of the diisocyanate. To prevent a complete change of state of the diisocvanate. a mechanical stirrer is used. Drops of glycol are added and react

more on page 90





VERTICAL FLIGHT Rotary or fixed wing. In either type of VTOL aircraft, control systems must provide precise and positive transfer of motion under all operating conditions. Regardless of size, a Shafer Aircraft Bearing will deliver greater load-carrying capacity and service life for its envelope dimensions and weight than any other self-aligning antifriction bearing available.

Shafer engineers have more experience with design requirements of successful vertical flight control systems than any other group in the industry. Consulted early in design stages, they can save valuable space and weight with Shafer Self-Aligning Aircraft Bearings.

Whatever your requirements for aircraft bearing performance, call on Shafer's specialized design experience. Shafer Bearing Division, CHAIN Belt Company, 801 Burlington Avenue, Downers Grove, Illinois

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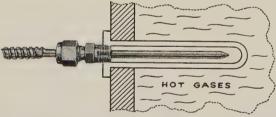
Autonetics' NADAR tells you exactly what happened up there

Was the pilot too quick on the trigger? Too slow? NADAR brings back the facts-a magnetic recording of everything the armament control system puts on the radar scope. The tape is ready for immediate playback—an invaluable tool for both flight training and flight testing. Remember...military pilots are always training. Autonetics

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Thermocouple Life Increased Up To 135 Times

With T-E's Ceramo® Construction



For measuring all types of process temperatures, T-E's "Ceramo" construction—ceramic insulation, metal sheathing—provides a tremendous increase in thermocouple life over conventional, openend types. In a typical application, enclosed hot junction, $\frac{1}{8}$ 11 O.D. "Ceramo" thermocouples were used recently in a hydro carbon cracking unit operating continuously at 1616° F. "Ceramo" thermocouples lasted 7 to 9 months—while 14 gage bare wire thermocouples lasted but 2 to 14 days. And there was no significant difference in response. "Ceramo" thermocouples are available in all standard calibrations. Overall diameters—1/25" to 7/16".

Write for Bulletin 325 - A

Thermo Electric Co., Onc. SADDLE BROOK, NEW JERSEY In Canada—THERMO ELECTRIC (Canada) Ltd., Brampton, Ont.

Write in No. 45 on Reader Service Card at start of Product Preview Section

SOURCES & IDENTIFICA-TIONS FOR REACTANTS

2,4-toluene diisocyanate (TDI) E. I. duPont de Nemours & Co., Inc., Organic Chemicals Dept., Elastomers Div Wilmington 98, Del.

Diethylene glycol Fisher Scientific Co., Chemical Manufacturing Div., P. O. Box, 375 Fair Lawn, N. J

2-butene-1,4-diol Genera. Aniline & Film Corp., Commercial Development Dept., 435 Hudson St., New York, N. Y.

1,4-butane diol General Aniline & Film Corp.

Triethylene glycol Carbide & Carbon Chemical Co., 12 S. 12th St., Philadelphia 7, Pa.

Ethylene glycol Carbide & Carbon Chemical Co.

Propylene glycol Fisher Scientific Co.

Dipropylene glycol Fisher Scientific Co.

with small quantities of the diisocyanate to provide the exotherm necessary for the basic reaction. To retard polymerization of the resin once the reaction is started, a solvent, benzene, is added in small portions (5-10 cm³) every five minutes.

GLYCOL type determines the reaction exotherm

The stirring is continued for 30 minutes after there has been a drop in temperature, signifying the end of the reaction. The reaction exotherm depends on the type of glycol used with the diisocyanate. The resins made in this way have a consistency similar to that of honey and a pot life of about 4-5 hours at room temperature.

These resins were used to prepare glass laminates by the following procedure: Twelve pieces of glass fabric (181 Velan A) were immersed, one by one, in the resin and then laid up at 90 deg to one another. The lay-up was wrapped in a sheet of red cellophane and placed between two highly polished and heated chrome-plated steel platens. The entire assembly was then subjected to a load in a molding press. After a specified time, the load was reduced until the assembly remained in a fixed position under a very slight load. The laminate

more on page 92

CHR ANNOUNCES

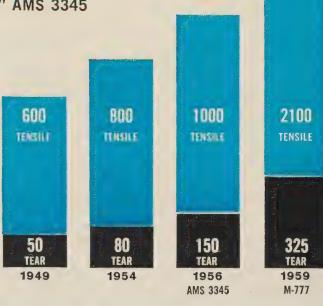
M-777 A NEW HIGH STRENGTH SILICONE RUBBER

100% Stronger Than "High Strength" AMS 3345

M-777 is an exclusive CHR development offering a combination of properties unmatched by any other silicone rubber. This new compound has physical strength equal to good general purpose organic rubber and may be used in applications where high tear strength or abrasion resistance is required.

M-777 doubles many of the original physical properties of AMS 3345. It is unaffected by time, weather, sunlight or ozone — remains flexible at -105°F - resists heat up to 500°F and has good electrical insulation qualities. Typical properties are listed below:

M-777 can now be specified for extrusions, moldings, extruded and spliced parts, or in combination with metals, reinforcing fabrics or with Teflon* bonded to the surface.



PHYSICAL PROPERTIES							
	As Received Properties	Dry Heat Resistance Aged 70 hours /400°F	Compression Set 70 hrs/300°F Percent of original deflection	Low Temperature Flexibility			
M-777	Durometer Shore A 50 Tensile Strength, psi 2100 Elongation, % 600 Tear Strength, lbs./in. 325	Durometer Change + 8 Tensile Change - 20 Elongation Change - 20	45	−105°F			
AMS-3345	Durometer Shore A 50 ± 5 Tensile Strength,psi 1000 Elongation % 500 Tear Strength,lbs./in, 150	Durometer Change 0 to + 20 Tensile Change - 50 Elongation Change - 40	73	-105°F			



CHR has made many important contributions in the development of silicone rubber compounds and techniques. The first truly high strength silicone rubber was introduced by CHR.

M-777 with 2100 tensile and over 300 tear strength, psi, considerably broadens the possible usage of silicone rubber and adds a new dimension to its many unique advantages. We invite your inquiries.



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Table II: Mil Spec vs Polyurethane Resins

	Specimen Thickness (in.)	Flexural Strength (psi)	Modulus of Elasticity
Mil-R-7575A polyester	0.125	50,000	2.50×10-6
Mil-R-9300 (USAF) epoxy	0.125	70,000	3.20x10-0
Mil-R-9299 phenolic	0.125	50,000	3.00×10-6
2-Butene-1, 4 diol	0.092	90,000	4.35×10 ⁻⁶
1,4-Butene diol	0.089	92,000	4.14×10-6
Diethylene	0.087	100,000	4.17×10-6



27 Volt DC shunt wound aircraft motor qualified to specification MIL-M-8609A (ASG) for small high speed pumps.



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was allowed to cool in this condition and then removed. The same method was used for preparing all the test panels.

Table 1 shows the types of laminates we made and some of their physical properties, and the Graphs show the results of postcure tests. As Table II shows, the diisocyanate laminates have better strength properties than conventional laminates.

We can see for Table I, greater flexural strength is obtained for laminates made with resins formulated with glycols containing four carbon atoms. Where 2-butene-1, 4-diol has been used (Formula 35), a postcure of two hours at 100 deg C shows increased strength properties. On the other hand, diethylene glycol (Formula 30) gives an equivalent value without such a postcure.

The Graphs suggest that a twohour postcure for 35 and 37 provides increased flexural strength. For 39, however, a decrease occurs, which is overcome by extending the cure to four hours. It should be noted also that further cure (eight hours) of 37 provides additional strength. But the outstanding feature is the superior strength shown for 35.

Glycols will be used in future tests

The curves for flexural modulus of elasticity show a reversal in behavior for 37 and 39 after the two-hour postcure. We cannot give an explanation for this at the present time. Again, the improvement in mechanical properties for 35 after the two-hour postcure is obvious.

On the basis of these data, the emphasis of future test work should be on the use of glycols with a four-carbon chain. Of course, we must remember glass laminates prepared with polyurethane resins have two major problems:

- They tend to support combustion.
- They cannot withstand external stress without deformation at high temperature (300 deg F).

Values for such important physical properties as tensile strength, impact resistance, and dielectric constant were not found in our preliminary tests. Future research will include these parameters, as well as the effects of gamma radiation.-End



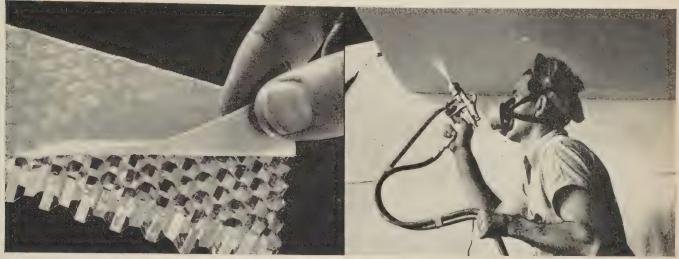
Frame 121/32 x 11/8





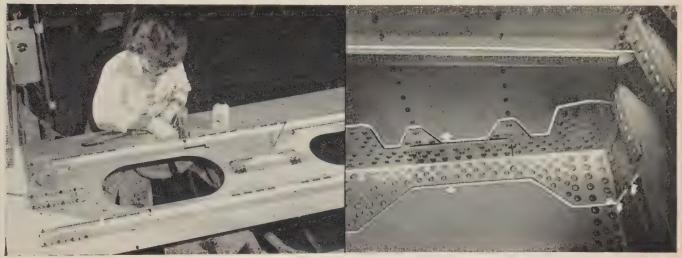
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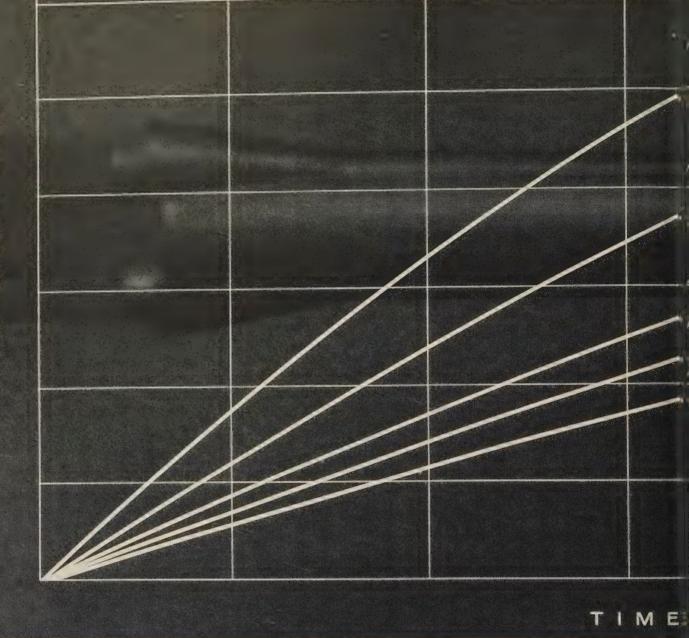


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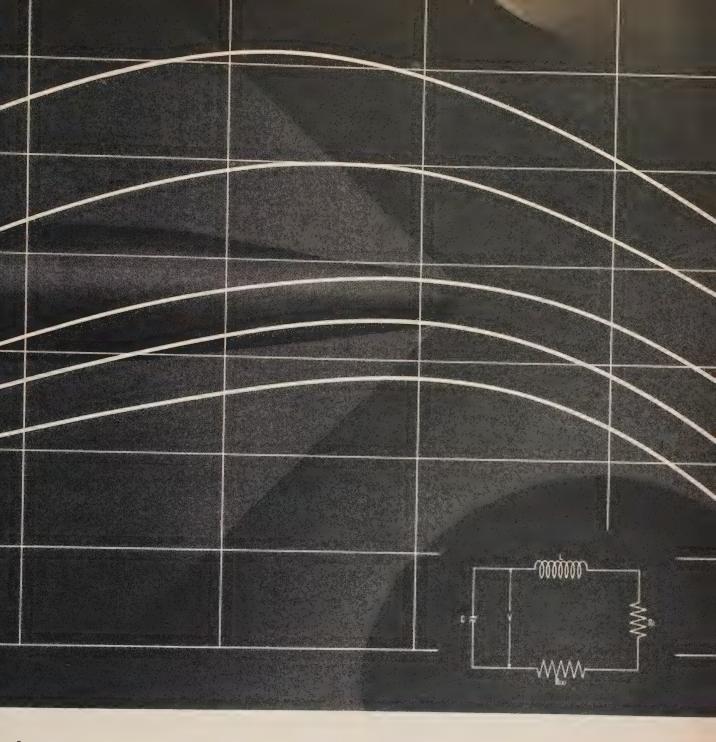
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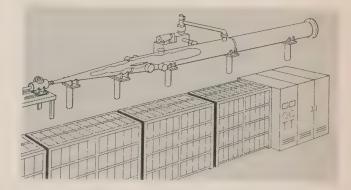


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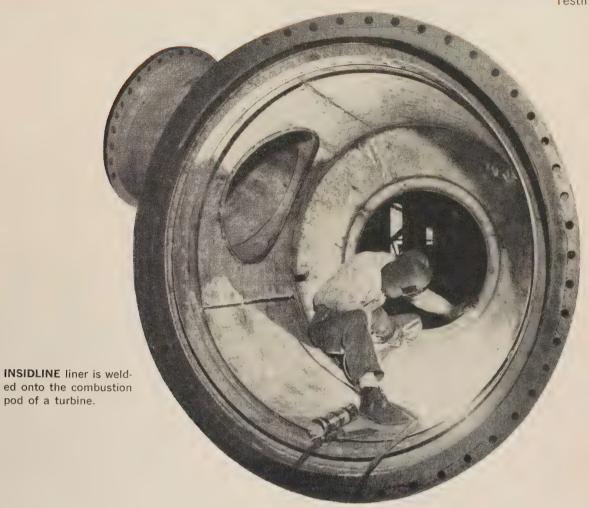
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KIN TEL-pioneer and leader in television systems for industry,

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Testing



Internal insulation

cuts hot gas ducting costs

With new research efforts involving pressurized gas at over 1000 deg F, the sky threatens to become the limit for steel ducting costs. To avoid this threat, this article advises, go to internal duct insulation.

by E. R. Thompson, Manager, Insidline Div , Baldwin-Hill Co.*

TEST temperature problems have taken on a new dimension since ducting in new facilities has had to carry pressurized gas at over 1000 deg F. The trouble is that the usefulness of mild carbon steels for ducting is very limited above 650 deg F. In their place, special steels must be used. In the process, material and fabrication costs naturally go up sharply.

One way to get around this problem is to insulate the ducting internally. In this way, you put a thermal barrier between the hot gas and the containing duct—yet,

^{*} Insidline Div., Baldwin-Hill Co., 1253 Breunig Avenue, Trenton 2, N. J.

high-energy fuel briefs from Callery

Callery opens office in Los Angeles—Fuel and propellant users on the West Coast can now contact Dr. Robert G. Brault, Callery's Manager, Western District, for helpful technical service. He has opened an office at 3141 Century Boulevard, Inglewood, California. Telephone: ORegon 8-9382. Dr. Brault was formerly Research Coordinator of the Project Zip high-energy fuel program at Callery's R & D Laboratories.

Diborane as fuel for rockets, ramjets, and turbojets—With a heat of combustion of 31,300 Btu/lb. and extremely good combustion properties, Diborane is an attractive fuel for air-breathing engines. Diborane, a gas at standard conditions, can easily be liquefied (boiling point -134°F). With modern insulating methods, it should be storable for long periods. Its specific gravity at a temperature slightly above its melting point (-265°F) is 0.56, so that it contains more Btu/gallon than JP fuels. Diborane has excellent heat-sink capabilities.

Recent calculations, based on the most recent thermodynamic data, show Diborane-LOX to have an I_{sp} of 349 sec. (1000/14.7 psia, shifting equilibrium). With its higher density and boiling point, it may be superior to hydrogen for some applications. Diborane will soon be available in tonnage quantities. Write for Technical Bulletin C-020 for detailed information.

HiCal® fuel now available—Since Callery's production of HiCal, high-energy fuel, will exceed immediate military test-program requirements for the next few months, substantial quantities of HiCal-3 are now available for authorized users with suitable security clearance. If you have been waiting to test HiCal-3 in engines or components, write now for specific information. Our HiCal-3 Handling Bulletin C-1100 is available on request.

New specific-impulse calculations—Specific-impulse data for several combinations of boron-containing fuels with various oxidizers have recently been calculated and tabulated. Most of these data are confidential, but Callery representatives would be pleased to discuss them with you on a classified basis.

Fire-fighting films on HiCal and pyrophoric fuels—The HiCal film shows the relative ease and safety with which a stable mechanical-foam blanket can extinguish burning HiCal fuels. Another 15-minute film illustrates the techniques available for combating fires of Trialkyl Boranes.

For information or loan of films, write to Defense Products Dept., Callery Chemical Company, 9600 Perry Highway, Pittsburgh 37, Pa.





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Dr. Robert G. Brault Manager Western District Callery Chemical Company

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H91300 200 400 600 800 1000 1200 1400 PRESSURE (PSI)

FIGURE 1: Unit weights of ducting carrying pressurized gas at various high temperatures for 18-in. 316 stainless steel pipe (dashed curves) and 24-in. carbon steel pipe (solid curve) in the same applications but with the temperature reduced below 650 deg F by internal insulation.

pressure is still transmitted to the duct wall. Since the temperature and pressure effects are now separated, manageable weights and thicknesses of carbon steel can still be used.

Whether internal insulation will reduce costs depends, of course, on the application. Figure 1 shows some of the factors affecting the economics of this question. It takes into account the fact that the insulated pipe must be larger in diameter to give the same flow area. As you can see, there is a big weight advantage in carbon steel and insulation at high flow temperature, increasing rapidly with temperature and pressure.

Insulation also is of value, even at lower temperatures, in high pressure cyclic operations in which heavy pipe walls absorb heat at the start of a cycle until their temperature approaches that of the flowing gas. Much heat is lost in this way, and there is a delay before the gas becomes fully effective at its destination. Insulation reduces these losses and delays.

Internal insulation naturally must be structurally sound. It must also be maintenance-free, since repairs would be costly, especially on small, inaccessible lines that would have to be dismantled. In most aerospace research applications, the construction also must withstand rapid depressurization.

Baldwin-Hill's patented Insidline* internal insulation basically uses a cylindrical steel liner to retain insulating material placed between it and the duct wall. It is anchored at one end by a frustoconical section, also made of steel

more on page 100

^{*} Registered trademark.





The Tapco Group of Thompson Ramo Wooldridge, Inc., Cleveland, Ohio, a leading manufacturer of aircraft components, choose KLIXON Three-phase Inherent Overtemperature Protectors for their "plug-in" type electric motor driven fuel booster pumps used in the Convair 880 Jet Transport. As Mr. John Urich, Senior Project Engineer, reports, "The KLIXON Three-phase Protector provides dependable motor temperature control consistent with operational and safety requirements."

The KLIXON Overtemperature Protector, used so successfully by the Tapco Group, is but one of many three-phase KLIXON Protector applications that insure maximum safety of the Convair 880.

In addition, KLIXON Aircraft Circuit Breakers protect single and three-phase electric circuits on the 880 Transport.

For information, write for new catalogs on KLIXON Inherent Overheat Protectors for High-performance Motors and KLIXON Aircraft Circuit Breakers.

Single-phase KLIXON D7271 miniature Circuit Breakers save 20 lbs. in weight on

KLIXON D6760-1 Circuit Breakers protect three-phase circuits on the 880 Transport by providing positive, simultaneous opening or closing of all three phases

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Motor Starting Relays • Thermostats • Precision Switches • Circuit Breakers

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and continuously welded to both the liner and the inside duct wall.

The other end of the liner telescopes into the next section. It remains free to expand lengthwise and equalize the pressure in the flow area and the insulation space. The shell takes the pressure—the liner is not subjected to differential pressure (Fig. 2).

The frusto-conical section has four basic functions:

- it supports the liner;
- it acts as a bulkhead to keep the hot gases from bypassing through the insulation space and so maintains the efficiency of the insulation and protects it;
- it presents a long, divergent heat path from the hot liner to the cooler shell;
- it automatically accommodates differences in the radial expansion of liner and duct.

Since liner and cone must retain strength at high temperatures and often resist corrosion and oxidation, they usually are made of stainless. However, as they aren't subjected to pressure differentials, they can be made from relatively light gage materials.

The liner operates at a temperature approaching that of the flowing gas, and some heat is passed to the duct wall through the supporting frustum. However, the long and diverging path offered by the conical section limits heat transmission. Therefore, although there is some rise in shell temperature at the point where the frustum is welded to the shell, this local application of heat is so diffused throughout the entire wall that its effect is small.

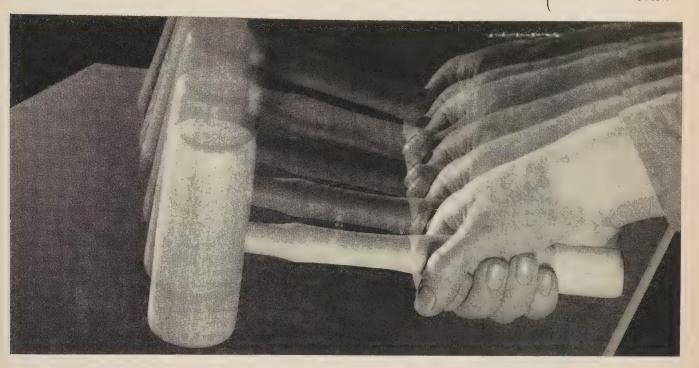
Radial expansion of the cylindrical liners is accommodated by the compressibility and resilience of the insulation material. The inner circumference of the cone and the liner operate at the same temperature. So their radial expansion is the same, and neither suffers any permanent distortion or appreciable stress.

Insulation thickness is determined by the temperature of the gas, the type of insulating material, and the allowable heat loss or shell temperature. When standard carbon steels are used, it would be enough to bring the wall temperature down to 600 deg F. In practice, however, it is usual to call for a much lower temperature for heat economy and personnel protection.

more on page 102

IMPACT VS. PLASTIC LAMINATES

It's more than "How Much" and "How Often"



It is easier to picture impact than to describe the effects of it upon plastic laminates such as Synthane. For one thing, impact is measured in several ways. In the standard A.S.T.M. (Izod) test notched samples ½" x ½" x 2½" are struck by a pendulum. This test is an accepted standard yet it seldom measures the impact behavior upon plasticlaminates. Reason: certaingrades of laminates are "notch sensitive", a condition which they may never meet in a practical application.

Nor does the Izod test indicate the ability of Synthane to resist repeated blows. Figure 1 shows how many times blows of a pre-determined intensity can be absorbed before the material breaks down.

Temperature Affects Impact Strength

Even repetitive impact is not the whole of the story. Temperature has an in-

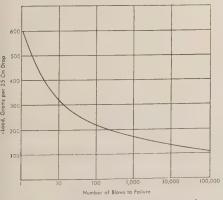


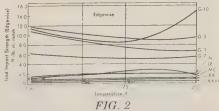
FIG. 1 Intensity of impact vs. cycles

teresting effect upon impact strength (Izod). The curves in Figure 2 show that at extremely low temperatures glass-base grades of Synthane actually improve in impact strength, while other grades improve as they are warmed. The impact strength of Glass Epoxy Grade G-10 improves sharply at temperatures above 75° F.

Impact Rarely Travels Alone

Like so many other properties of laminates, impact strength can rarely be regarded alone; it must be related to other properties required for the application. A sheet of Synthane has less impact strength than an equal thickness of steel. But steel is over seven times heavier and is a conductor, not an insulator. It is the combination of other properties desired, including impact strength, that is decisive.

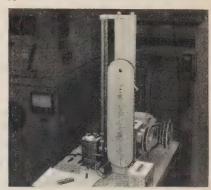
Typical applications for Synthane's combined properties under impact conditions are (a) Grade LE Synthane in the shock struts of Airplane Landing Gear (light weight, low coefficient of friction, compressive strength, wear and shock resistance); (b) Welding Tong Insulation, made from G-5 Synthane



Effect of temperature on impact strength

(high resistance to impact, excellent resistance to heat, and good dielectric strength); (c) Ignition Breaker Arms of Grade C molded-laminated Synthane (impact resistant, wear resistant, dielectrically strong).

If you have any question about the selection of the proper grade of Synthane for your impact application refer it to us directly or to a Synthane representative. Make sure you obtain the most of what you want for the money. For information write Synthane Corp., 55 River Road, Oaks, Pa.



Synthane laboratory machine for measuring impact fatigue.

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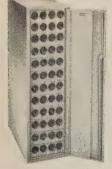
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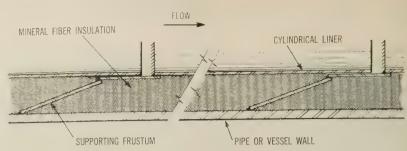


FIGURE 2: Typical cross-section of Insidline insulation and pipe wall.

Since pressure is the same in the insulation as in the flow area, sudden depressurization of the line would subject the hot and comparatively weak liners to a collapsing pressure—unless we provide for quick aspiration of gas from the insulation space. There is also the problem of keeping insulation materials from entering the air stream.

Figure 3 shows a construction that allows fast "breathing" from the insulation. The lining is made in cartridge form, with the insula-

source



FIGURE 3: Typical cross-section showing "fast-breathing" Insidline construction for quick depressurization.

tion enclosed in a perforated outer jacket. The jacket diameter is so chosen that an annular space remains between the jacket and the more on page 104

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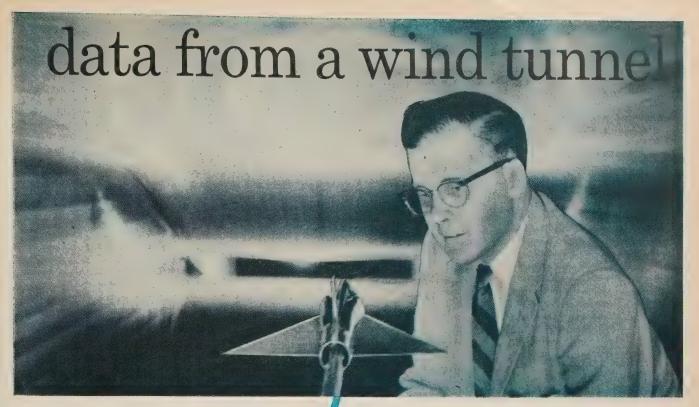
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F-106 model in Convair's supersonic wind tunnel at San Diego, California.

MicroSADIC...Consolidated's new all solid-state data processing system... is now in action sampling, digitizing, and recording at the maximum speed of computer input. In one high-speed wind tunnel, 25 force mode channels and associated block gaps are recorded by this integrated system in less than 20 milliseconds. In the pressure mode sampling of all 125 data channels requires only 0.8 seconds. These are just some of the capabilities of this flexible automatic system . . . a system that can also be custom-tailored to rocket test, thermostructure, or telemetry data reduction. Full information is in Bulletin CEC 3020-X5.

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Comparison of Air Pipe or Vessel Requirements for Some Insidline Applications

Service Co	onditions	Pipe or Vessel Data					
per commence of the site of th	-	Carbon Steel with Internal Insulation			Stainless Steel without Internal Insulation ¹		
Temp (deg F)	Pressure (psig)	OD (in.)	Wall (in.)	Weight (lb/ft)	OD (in.)	Wall (in.)	Weight (lb/ft)
1300 1300 1050 1000 ³ 1500 ³ 1100 ³ 1800 ³	100 100 200 1000 2300 2400 185	36 67 ¹ / ₂ 54 44 ⁷ / ₈ 28 67 ¹ / ₂ 48	1/2 3/4 1/2 17/16 2 43/4 1/2	190 535 286	32 62 52	9/16 1 ¹⁵ /16 1 ¹ /8	191 619 618:

(1) Approximate figures based on ASME Boiler & Pressure Vessel Code and maximum allowable stress values for unfired pressure vessels for welded SA-312 (TP316). (2) Based on 85 per cent of allowable stress for chrome-molybdenum seamless alloy SA-335 (P92). (3) No comparison because unprotected vessels not feasible in this application. (4) Proposed installation.

inner surface of the duct. The insulation now can "breathe" into the annular space through the entire jacket area.

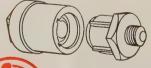
From here the gas passes into the flow area through the opening provided between the cartridges. The size of this opening depends on the application and is chosen so that the safe differential pressure on the liner isn't exceeded. Dust is kept out of the system by a filter between the insulation and the jacket. Write in No. 54 on the Reader-Service Card for more information.—End

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Designed for demanding hydraulic systems, On Mark's new 5-5012 series couplings meet and exceed Mil-C-25427 ... with a rating of 4000 P.S.I. For applications where the severe impulse requirements of Mil-C-25427 are not required, this coupling may be used with operating pressures up to 6000 P.S.I. The unique locking device, an integral part of the coupling, gives a full 360° grip on the mating part for maximum locking power. It will withstand extremely high pressure and shock loads, yet can be coupled or uncoupled without special tools, with no leakage. Available now in sizes from ¼" up.



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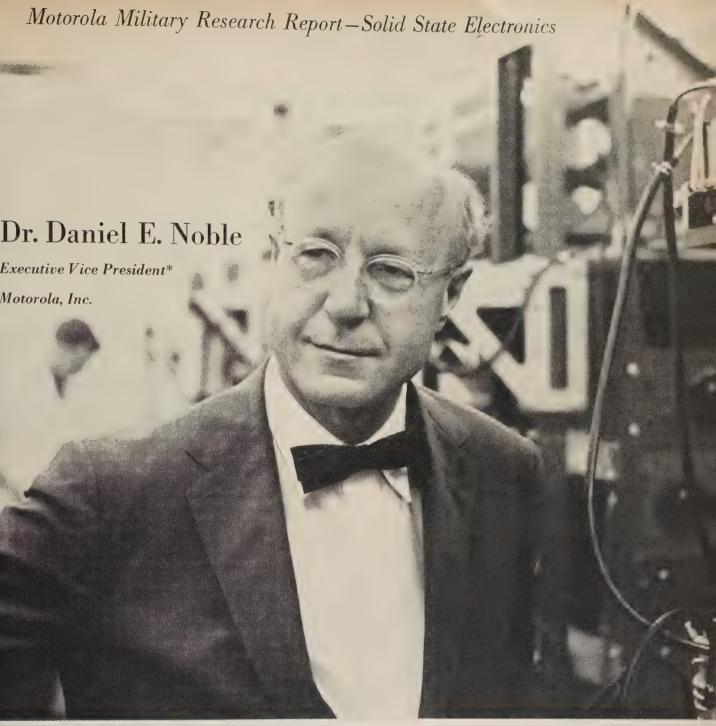
Basic coupling can be fitted with indexed "keys," as illustrated, to prevent mismatching different fluid lines.

For full information please contact

ON MARK COUPLINGS, INC.

4440 York Boulevard, Los Angeles 41, California Telephone CLinton 4-2278

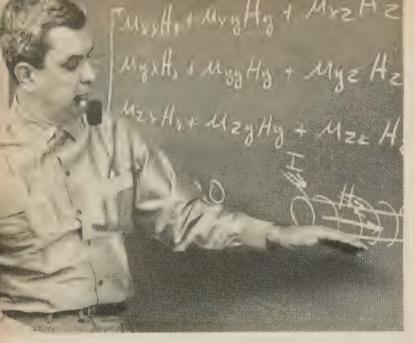
Representatives: Airsupply Company, Beverly Hills, Calif.; Aero Engineering Company, Mineola, Long Island, N.Y. - Divisions of The Garrett Corporation



*DR. NOBLE IS VICE PRESIDENT IN CHARGE OF THE COMMITTER AND INDUSTRIAN FURTHER WORLD THE SEMINAR OF THE PROPERTY OF THE ARCHITECTURE OF THE SEMINAR OF THE WORLD THE W

"In this new era, Solid State Electronics will spread its influence to every form of human endeavor and will contribute substantially to scientific achievement in all fields."

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John C. Cacheris, right, manager of the Microwave Applications Laboratory, and a member of his staff inspect a parametric amplifier, one of several devices now being produced by Motorola's Solid State Dept.





James R. Black, manager of Motorola Microelectronics Laboratory, heads work which leads toward the mass production of economical microelectronic components so small that several would fit on the period that ends this sentence.

Ferrimagnetic principles are demonstrated by scientist in charge of Motorola's Solid State program, Dr. H. William Welch, Jr., director of research and development, Military Electronics Division. Dr. Welch as a University of Michigan professor established that school's Solid State laboratory and introduced new curricula in Solid State devices and their applications. He holds an I.R.E. Fellow Award for contributions to development of solid state devices and microwave tubes.



Typical of solid state materials now being offered for sale by Motorola are these ferrite rods and bars being examined by Donald L. Fresh, manager of the Solid State Materials Laboratory.

Imaginative leadership plus the most modern of laboratory facilities have helped foster a creative environment that is attracting top talent to Motorola. Here, Dr. Arthur L. Aden, associate director of research and development for Motorola's Military Electronics Division, show a new member of his staff equipment for photographing printed circuits. Dr. Aden welcomes inquiries from qualified engineers and physicists who would like to join his department.



How Solid State Electronics is shaping the future

MILITARY ELECTRONICS—industry as well—is being radically changed by rapid advances in solid state technology. Predicted for the near future are computers small enough to fit in the palm of a hand, receivers that will detect the weakest signals from distant satellites.

Motorola's highly experienced Solid State Department, in close cooperation with the Semiconductor Products Division, is advancing the state of the art on several fronts, one of the most promising of which is microelectronics.

By making use of crystalline functional circuit elements created in volume quantities by surface etching or film deposition methods, Motorola researchers anticipate they will soon be able to design equipment with component densities of tens of millions per cubic foot.

This high density will result in a great reduction in systems and computer size coupled with a significant increase in reliability, and it will lead to the development of self organizing computers for such complex tasks as the solution of military logistics problems and space guidance.

In microelectronics and in other areas, Motorola scientists, including those of the Semiconductor Division, are investigating the ferroelectrical, ferrimagnetic, piezoelectrical and pyroelectrical characteristics of monocrystalline and polycrystalline solids. New materials possessing these useful characteristics are created and produced in the Materials Laboratory. Typical applications: newly developed ferroelectrical or piezoelectrical materials to be used in transducers for submarine detection.

At present, the Applications Laboratory is making extensive use of ferrites and semiconductors in the development of broad lines of isolators, circulators and parametric amplifiers. The latter device has already demonstrated its worth in satellite-tracking radars, IGY research receivers, uhf television receivers and radio. In the study and design stage are new and advanced ferrimagnetic devices such as microwave switches, ferrimagnetic limiters and semiconductor switches.

Still another research frontier where striking preliminary results have been achieved is a low-voltage facsimile paper for the transmission of teletype and other information. Applications in the fields of combat surveillance, logistics control and other important military programs are foreseen.

Military Electronics Division's expanding capability in solid state electronics is described in a new booklet entitled: "Solid State Frontiers at Motorola." Request your copy from Technical Data Service, Motorola, Inc., Military Electronics Division, 8201 East McDowell Road, Scottsdale, Arizona.



Engineers and Physicists interested in career opportunities are invited to write: Motorola, Inc., Military Electronics Division







Some Ideas



for your file of practical information on drafting and reproduction from

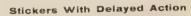
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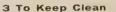
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Production Engineering

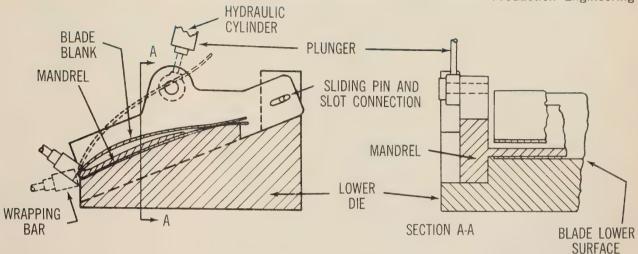


FIGURE 1: The nose of the blade is formed in this device. When extremely small nose radii are needed, a milling cutter can be used to form a small groove before the

blade is put into the forming device. The groove can be filled with braze alloy in the next step to preserve strength.

Sheet metal rotors

cut weight and cost

Brazed sheet metal units, it's reported, can provide weight savings of up to 60-70 per cent for some rotor assemblies—and within tolerances as rigorous as those for integral rotors.

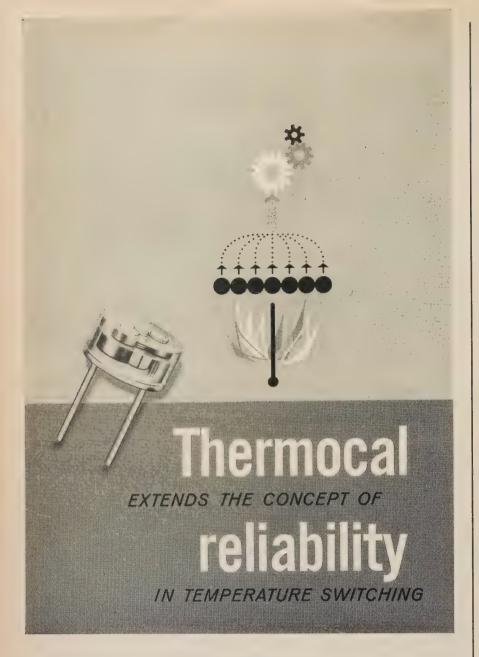
SHEET METAL rotor assemblies promise to save a lot of weight in today's jet engines. Stalker Development Co., 903 Woodside Ave., Essexville, Mich., for instance, has succeeded in making such assemblies some 60-70 per cent lighter than their machined counterparts.

Rotor hubs normally are machined from steel forging. Since the hub webs are very thin and the rim is thick, Stalker engineers point out, often about 11 times as much material is machined off as is left in the finished hub. In addition, the blades usually are machined with special cutting equipment or die-forged with a subsequent dressing operation.

To cut the weight and cost of rotors produced by such methods, Stalker decided to look into making both blades and rotors from sheet metal. One of the problems with sheet metal blades is warping during the brazing operations, which normally can be prevented only if special fixtures are used. To overcome this effect, Stalker decided to make the blades in such a way as to forestall the development of internal stress.

In the Stalker process, the blade blank is first stretched over dies to precisely form the upper and lower surface of the blade envelope (Fig. 2). The nose portion is curved about a longer radius than is finally required, but the upper and lower surfaces are essentially in final shape. To form the nose, the blank

more on next page



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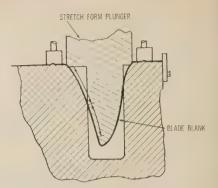


FIGURE 2: The first step in making sheet metal rotor blades is the stretch-forming of the blank to obtain upper and lower surface con-

is placed in a device consisting of a base die shaped to conform to the lower surface and a mandrel hinged to the base (Fig. 1) by sliding pin-and-slot connection. An operating plunger, actuated by a hydraulic cylinder, clamps the blade between die and mandrel. A wrapping bar is then used for the forming operation.

The trailing edges are spotwelded together, and the blades placed in a simple fixture for brazing (Fig. 4). The stretching operation during forming, engineers state, eliminates internal stresses, so that the blade can be passed through the brazing furnace just resting against a support. This, process it's claimed, can be repeated several times without any effect on the blade shape. After brazing, the excess trailing-edge material is cut off and the surfaces are deburred and smoothed to as sharp a section as desired.

Hollow blades conserve rotor weight

Of course, the sheet metal rotor can be made with other than sheet metal blades. However, engineers say, if hollow blades are used, the centrifugal loads on the rotor rim are greatly reduced. Lightweight rims, it is stated, can then be used that, together with the hollow blades, reduce the loads on the hub web or disk.

Figure 3 shows a typical sheet metal rotor assembly. The blade envelope is placed over a stem that extends radially inward between the side plates. The stem is first spot-

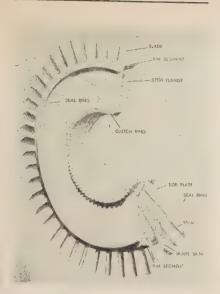


FIGURE 3: Typical sheet metal rotor for axial flow compressors made by Stalker. This unit, it's stated, weighs 30 lb, as against 75 lb for its machined counterpart, and costs about 10 per cent less to make.

welded to the plates and then furnace-brazed with copper in a controlled atmosphere. The individual rim segments are positioned between the blades. They have flanges on each of their four sides that are brazed to the blades and the seal rings.

The side plates are spot-welded and then brazed to flanges on the toothed clutch rings. The teeth of one ring are designed to mesh with those of the next rotor to give a multi-stage design.

The rotor in Figure 3 has a 32-in. tip diameter. Blade shell wall thickness is 0.01 in. A silver alloy fillet is used to fair each shell into the rim surface. The teeth were machined after the brazing operation had been completed.

An inexpensive brazing fixture is used

Stalker also points out that no intricate fixtures are used to braze rotor assembling. In a typical case, the rotor assembly rests on a series of pads in a holder that look like a frying pan. No supports beside the pads are needed, it's stated.

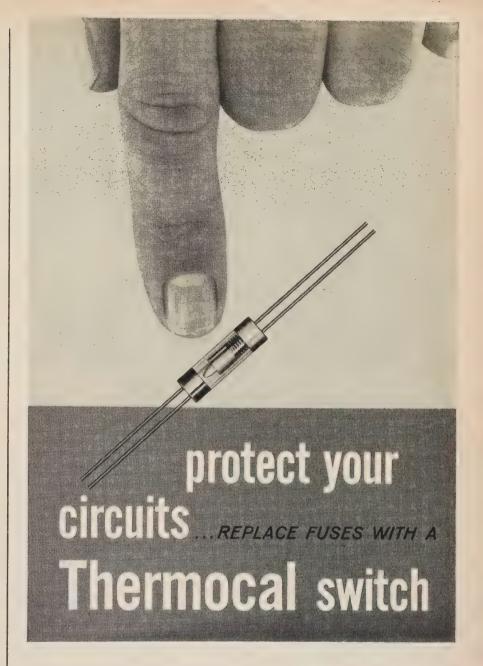
The pads are coated with milk or magnesia to keep them from fusing to the rotor during brazing. The rotor may be heated to 2000 deg F several times without ex-

more on next page

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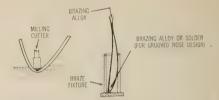


FIGURE 4: Blade trailing edges are brazed together in this simple fixture.

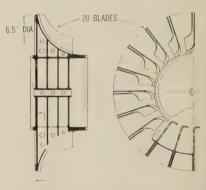


FIGURE 5: Small sheet-metal-brazed radial-flow impeller.

ceeding blade dimension tolerance of, for instance, ± 0.003 in., it's claimed.

Company engineers emphasize that their experience shows brazed structures can be as reliable as integral ones. To get such reliability, they explain, you must design the assembly so that the joints are easy to inspect and you can tell with certainty whether they are made or not. A continuous series of inspections, including visual, X-ray, Zyglo, etc., is used.

An example of the Stalker brazing approach is shown in the rotor assembly of Figure 6. The brazing alloy is placed on the tongue inside the rim while the assembly is being made. When the alloy melts, it flows outward and visual Zyglo inspection, it's claimed, will show whether a complete joint has been made—since, Stalker engineers point out, the alloy must only flow a distance equal to the wall thickness. In addition, test coupons of two pieces of sheet metal are included.

For this rotor, the stress level in the side walls of the rim at the radial level of the tongues is about 15,000 psi radially and 30,000 psi tangentially. Unit stress at the junc-

more on page 114

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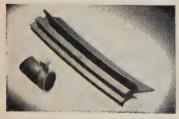


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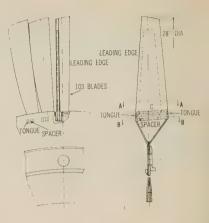
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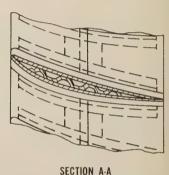
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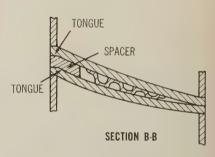
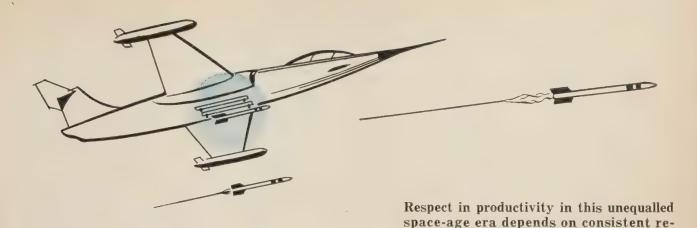


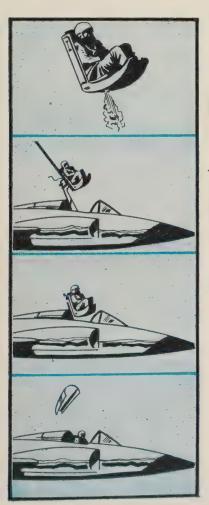
FIGURE 6: Details of another rotor assembly, showing the method of blade attachment. The root ends of the blades are indented to form tongues that engage the side walls of the rim. Spacers fill the gap between the side walls of the root end. The rim segments are integral, with the side walls bonded together at C by a scarf joint.

tion of the side walls is 6000 psi.

Other types of structures are also being made of sheet metal, such as the centrifugal, unshrouded impeller of *Figure 5*. In this design, the vanes are slotted at their root ends to receive the peripheral portions of the four supporting disks. Circle No. 63 on Reader Service Card for more information.—IS



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books

High Temperature Effects in Aircraft Structures, edited by N. J. Hoff. Various leading authorities contributed chapters to this AGARD sponsored book, including new and previously unpublished information. Pergamon Press, 122 E. 55th St., New York 22, N.Y. \$12.

Artificial Satellites, by A. Shternfeld. This is a translation, by the Technical Documents Liaison Office, Wright-Patterson AFB, of a book by one of the top Russian scientists. A wide range of topics is covered from basic theory to hardware, propellants, communications, etc. Office of Technical Services, U.S. Dept. of Commerce, Washington 25, D.C. \$6.

The Metal Thorium, the proceedings of 1956 conference on thorium. This book includes papers on all aspects of thorium: nuclear and non-nuclear uses, thorium fuels, properties, production methods & processes, etc. American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio. \$10.

The Helicopter, by Jacob Shapiro. Written for the general reader, this covers the history of the 'copter, its uses and basic principles in its design. The Macmillan Co., 60 Fifth Ave., New York 11, N.Y. \$4.50.

Guided Missile Engineering, edited by A. E. Puckett and Simon Ramo. Eighteen leading missile engineers have contributed articles covering the latest state-of-the-art in their various disciplines. McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N.Y. \$10.

Gas Turbines for Aircraft, by A. W. Judge. Typical gas turbines and their component systems (fuel, combustion, lubrication, control, etc.) are discussed as well as such other considerations as thrust reversal, exhaust silencing, etc. A section is also devoted to elementary thermodynamics of gas turbines. The Macmillan Co., 60 Fifth Ave., New York 11, N.Y. \$12.



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Ryan's rapid growth in electronics is creating new opportunities for engineers and technicians

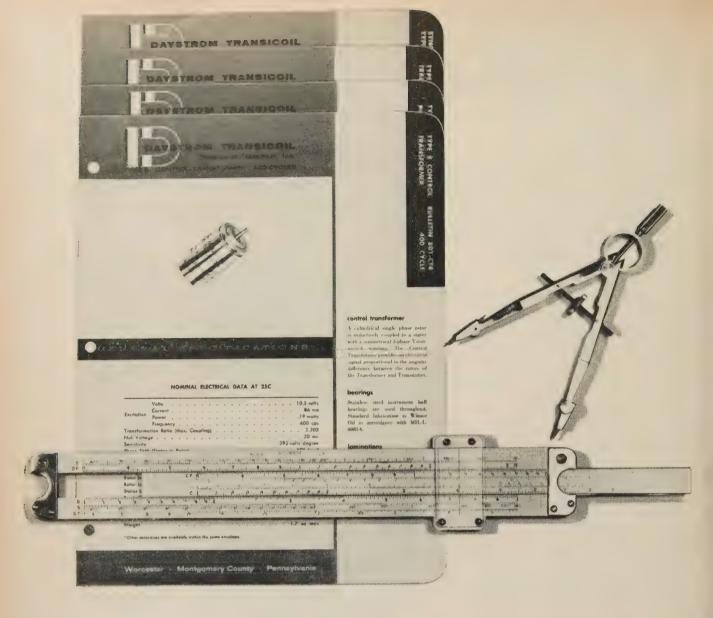
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space/aero electronics intelligence

NO INCENTIVE for reliable design is offered under present military contract procedures, charges Art Wulfsberg, assistant director of R&D at Collins Radio. Writing in the Collins Signal, he claims the practice of awarding contracts to the "lowest apparently qualified bidder" is at fault. It leaves an opening for the "less-than-conscientious contractor to pay only token respect to the reliability aspects of the design", he says.

Wulfsberg figures an effective reliability program can easily double or even triple development costs. When the competent and conscientious bidder includes these costs in his price, he is "likely to find others underbidding him with discouraging consistency," Wulfsberg points out. The bidder can, claims the Collins researcher, bid low enough to win the contract and then spend his own money on reliability in hopes of getting it back by negotiation. But, he says, apparently speaking from experience, there's no guarantee the contractor will ever recover these funds.

Separate, concurrent reliability contracts to go with development contracts?

TO MAKE RELIABILITY practical, Wulfsberg suggests that, when a development contract is let, a separate, concurrent contract be made to cover the reliability aspects. He also suggests the government set up a system of royalty payments for original designs.

LATEST "ASTRONERTIAL" system designed by Nortronics for future weapon systems and scientific satellites is, according to the company, ½0 as large, ½0 as heavy, and four times more accurate than the latest astronertial system Nortronics is building for Snark. The new A-5 system was developed with company funds and uses much of the hardware of Nortronics' Lins (Lightweight inertial system).

Lins weighs slightly more than 100 lb and has digital inputs and outputs—no analog-digital conversion is needed. Vibrating mass-type accelerometers and pulsed gyro pickoffs are reportedly used.

Nortronics hopes to interest the Army in using Lins for copters, drones, and aircraft. The company is also working on V-Lins (Very Lightweight inertial systems), a still lighter version.

ELECTRONIC SHIELD defensive system for NAA's B-70 Valkyrie will be built by Westing-

house Air Arm under a multi-million dollar USAF contract. "The defensive system will make use of electromagnetic and other techniques to make it difficult if not impossible for enemy aircraft or missiles to successfully attack the B-70," according to NAA v-p Raymond H. Rice.

Minuteman telemetry contracts let by Boeing

ADVANCED DIGITAL telemetry system will be built by Radiation Inc. for the Minuteman program. According to the company, this will be the first use of digital telemetry with an operational missile. The contract, let by Boeing, will run into millions, says Radiation.

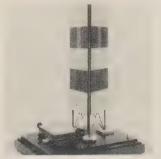
FM-FM TELEMETRY for Minuteman ICBM will be "designed, developed, and fabricated" by United Electrodynamics, Pasadena, Calif., under a \$0.5 million Boeing subcontract.

AMMONIA MASER clock is being built by Hughes Aircraft under a \$200,000 NASA contract. Including a gaseous-beam maser and associated electronics, it will weigh around 30 lb. It will be placed in a future satellite primarily to check Einstein's general theory of relativity.

If the theory is true, Hughes scientists calculate, the time difference between their clock ticking at a 24-kmc rate in an 8000-mile-high, 18,000-mph satellite and an earthbound clock should be one second in 60 years.

Hughes is proposing that its clock also be used to check the special theory of relativity, to measure precisely the geometric shape of the earth, to find out whether space is the same in all directions, and to measure the velocity of light.

more on next page



Cover story—Model of experimental height finder antenna designed by Maxson for FAA. Passive, fixed system works in Sband, can pick up targets illuminated by search radar (ASR) at 50 miles. Design was picked from among 20 proposals.



space/aero electronics intelligence

BUREAU OF STANDARDS and ITT Labs are also working on atomic clocks. NBS' approach is based on optically excited rubidium atoms. ITT is studying the characteristic frequencies associated with sodium and cesium atoms.

HOUND DOG will be the first missile to use Kollsman Instrument's Astro Tracker automatic celestial navigation system. Autonetics let a \$5 million contract to Kollsman for the trackers and tooling and test equipment. Kollsman is already producing the system for the Boeing B-52 and Convair B-58.

EAGLE GUIDANCE seeker contract was awarded to Sanders Assoc. by Bendix. This was as expected since Sanders was a member of the seven-company team that won the missile system contract for the missile.

Canadian DR computer for German F-104s uses preset pushbutton control

PUSHBUTTON dead-reckoning computer made by Computing Devices of Canada, a Bendix affiliate, will go into the Lockheed F-104s slated for the West German air force. The system, developed a few years ago, weighs just under 25 lb. It has five pushbuttons that are preset before takeoff with the positions of five destinations. Pushing one of the buttons in flight shows heading and distance to the selected destination on a pilot's indicator. Heart of the system is a 13.5 lb analog computer.

The contract now amounts to \$1.6 million but is expected to go to \$6 million before all the West German Starfighters are equipped.

THE MAGNETORESISTOR, a new and interesting electronic component, is available in experimental and production quantities from its developer, Ohio Semiconductors. The new device is a semiconductor (indium antimonide is used in the available units) in which electric resistance is a function of an applied magnetic field. Resistance will change 10:1 in an applied field of 10 kilogauss. At lower magnetic field intensities, the device obeys an approximate square function, says the company.

Noise of the magnetoresistor is very low—roughly on the order of Johnson noise. Response time theoretically is limited only by the relaxation time of the charged carriers.

TYPICAL applications of the magnetoresistor are contactless potentiometers, amplifiers, voltage and current regulators, computing elements, squaring devices, modulators, and transducers. The resistance of the indium antimonide type is one ohm ± 20 per cent; the power rating to $\frac{1}{4}$ W (both values at room temperature).

Fourteen electronic systems by Collins in Mercury communications

PROJECT MERCURY'S communications will include 14 electronic systems provided by Collins Radio. These will supply (1) voice communications for the pilot during the orbital phase, (2) command functions during launch, orbit, and reentry, (3) telemetry of scientific and aeromedical data during launch, orbit, and re-entry, (4) satellite tracking, (5) voice communications and beacons for rescue when the satellite is brought back to earth, and (6) antennas for all phases of the mission.

Both HF and UHF voice communications will be supplied. A conventional, partly transistorized, crystal-controlled 10-W HF transmitter will be used for voice during orbit. A companion HF receiver will be a completely transistorized TRF (tuned-radio frequency) type with a crystal input filter.

THE HF RECOVERY voice transmitter-receiver will be identical to the HF orbital communications set, except that it will have an auxiliary 24-hr battery power pack and will transmit only one watt instead of 10. (There will be no transmitter power amplifier.)

The UHF orbital voice transmitter will put out two watts of crystal-controlled power. The companion receiver is a completely transistorized, single-conversion, superheterodyne type.

All HF and UHF gear will be single-foamencapsulated to get low weight and ruggedness in minimum volume.

MOTOROLA, under subcontract to Collins, will supply two FM command receivers with paralleled inputs and outputs for redundant operation. The receivers are completely transistorized and provide 20 DPDT functions, any six of which may be operated at one time.

Other Collins electronic subcontracts for Mercury include: telemetry to Texas Instruments, C- and S-band tracking beacons to ACF's Avion Div., VHF orbital tracking beacon to Cooper

more on page 124



Developed especially for the rigorous demands of airborne service, the Series AM17 circuit breaker is now proudly flying with such dependable aircraft as Douglas' huge C-133.

The rugged AM17 operates on Heinemann's wellproven principle of magnetic actuation with hydraulic time delay. No de-rating, no compensation for ambient temperature or vibration necessary.

Easily ganged in the field for Companion-Trip® multipole applications, the AM17 is available with AC ratings of 120/208V, 60 cycles, 120/208V 400 cycles, or 30V (±2V) DC.

Current ratings can be matched to your exact specifications. That means you can have the AM17 with any odd or fractional current value required up to a maximum of 50 amperes. This is the kind of precise protection necessary to assure safe continuity of service under any in-flight conditions.

Full details, including environmental test data, are furnished in Bulletin T-3303. Write for a copy.

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Development, Monrovia, Calif., and HF and UHF rescue beacons to Simmonds Aerocessories, Tarrytown, N.Y.

MERCURY'S ANTENNAS will be quite unique. During launch and orbit, a modified biconical horn will serve as a common antenna for all HF, VHF, and UHF functions. When the drogue chute is ejected (during recovery), this antenna will be jettisoned and a broadband monopole will erect from the top of the parachute container. UHF voice, command and telemetry functions will all be multiplexed to this antenna.

After the vehicle has landed and the parachute is separated, communication will be via a balloon-supported HF wire antenna.

For the C- and S-band beacons, three dualband, circularly polarized radiators will be arranged around the capsule. Melpar will supply these antennas under subcontract to Collins.

RADAR MATCHED FILTERS have been developed by Westinghouse's Electronics Div., Baltimore, Md., and are being used in SPS-37, one of BuShips' latest air search radars. According to Westinghouse engineers, their system is similar to but simpler than the Chirp matched-filter system developed by Bell Labs.

Nortronics checkout system for Ajax, Hercules, Hawk, Corporal, Lacrosse, Sergeant

UNIVERSAL missile checkout system developed by Nortronics is designed to check out Nike-Ajax and -Hercules, Sergeant, Corporal, Hawk, and Lacrosse. Nortronics has completed a prototype and will demonstrate it in connection with the Western Electronics Convention (Wescon) in San Francisco, Calif., late this month.

The prototype of the "Universal Field Maintenance Shop Set" was built under an Army contract. Nortronics will study application of UFMSS to Jupiter and to the SS-10 and SS-11 artillery missiles.

The company has also adapted the universal checker to Polaris and expects to have a prototype of this version by next July.

WORK on tunnel diodes is in high gear at GE's Research Labs. So far GE has made the devices from silicon, germanium, gallium arsenide, gallium antimonide, and indium arsenide. GE's Semiconductor Products Dept. expects to offer limited experimental quantities starting in September. First samples will cost \$75 each. Production units

eventually should cost less than transistors, GE estimates.

The company is very enthusiastic about the future of the tunnel diode. Dr. Guy Suits, director of research, says the device "could lead to revolutionary changes in the electronics industry."

BECAUSE the tunnel diode depends less on the structural perfection of its crystal than does the transistor, it is much less affected by nuclear radiation. GE claims the tunnel diode is 1000 times better than a transistor in this respect. Also, says GE, the tunnel diode, being simpler, in the end will be much smaller than present transistors.

The company claims its new device will be little affected by environmental conditions. It points out that silicon tunnel diodes made by GE researchers will operate up to 650 deg F.

Some characteristics of tunnel diodes as given by GE:

- maximum oscillation frequency—2 kmc (10* kmc in a few years; 100* kmc is conceivable);
 - minimum power requirements—10⁻⁶ W;
- equivalent noise temperature (for amplifying a 1000-mc signal)—100-300 deg K;
- switching speed—fraction of a millimicrosecond.

Combination of tactical and navigation data on single CRT to be studied

FEASIBILITY of presenting both tactical and navigational information on a single cathode ray tube will be studied by ACF's Avion Div. The contract was let by Douglas Aircraft and is part of the Army-Navy Instrument Program (ANIP).

Avion has already developed a closed-circuit TV navigation display system for aircraft under a WADC contract. For Douglas it will attempt to integrate the navigation data with such information as a range limit circle, command data, and position of air and ground targets.

PHASE MULTILOCK communications stirred up a lot of industry interest at the IRE Military Electronics Convention in Washington in May. As described by two of its designers from Robertshaw-Fulton Controls, Anaheim, Calif., the system is a binary, coherent-predicted-wave signaling method that uses phase-shift keying. Binary-coded intelligence is impressed on a carrier or subcarrier as a predetermined phase shift and retrieved at the receiving station by comparing the phase of the incoming signal with that of a stable reference.

Advantages are less bandwidth and near-optimum S/N for a given bit rate.



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Cooling systems

for high performance electronics

You just can't get full rated output and reliability out of aerospace electronic equipment without cooling. For best results, the cooling system and the electronic package should be designed concurrently.

by Howard Otto, Design Engineer, United Aircraft Products, Inc.*

Many Factors enter into the design of a cooling system for electronic equipment. On top of such basic considerations as functional requirements and environments come questions of development cost and producibility and maintainability.

Since the heat to be dissipated and the specified control temperature usually are constant values, the electronic equipment manufacturer can provide these at the first stages of design. Ambient temperature shouldn't be used as the sole definition of the thermal situation. You should also know the evironment prior to installation, you should define the thermal condition due to electronic and aerodynamic heat concentration that results when the equipment is operating (Table 1).

In other words, the entire flight envelope should be known. Aerodynamic heating alone can determine, for instance, where both the cooling system and the electronic equipment may be located. When the envelope includes both static and full flight operation, this again affects the cooling system design—particularly in the case of VTOL aircraft and missiles.

The surface temperature of each electronic component must be known if it is to be kept within required limits. The components will be either heat generators

* United Aircraft Products, Inc., P. O. Box 1035, Dayton 1, Ohio.

(vacuum tubes, resistors, power transformers, power transistors) or thermally sensitive units such as capacitors, crystal diodes and transistors. Space limitations and, in case of extremely high altitudes, the low density of the air will restrict your choice of cooling system that can be used.

In many missiles, electronic equipment temperatures must be controlled within tight limits, and prelaunch cooling must therefore be provided. On the other hand, when a wide temperature range is permissible and overall missile operating time is short, the heat capacity of the equipment by itself will often be enough to limit the temperature rise. Or, as in the case of some airlaunched missiles, the prelaunch environment may have sufficient heat transfer potential to maintain proper operating conditions.

Supplementary cooling capacity is definitely needed for ground-based missiles that need extensive standby and checkout procedures. In certain other cases, inflight temperature control of missile electronics can be achieved by transferring heat to other non-critical components in the system. As flight duration increases, so does the need for an external heat sink.

Fundamental to every airborne cooling system is a reliable method of dissipating or transferring any heat developed by the electronic equipment. The job can be done efficiently by either conduction, convection, or radiation—using such equipment as cold plates, heat exchangers, mechanical refrigeration, or expendable refrigerants.

In low performance aircraft, it often is possible to pass ram air (expanded or unexpanded) through the electronics for adequate cooling of the heat-generating elements by direct contact.

For high performance requirements, the most reliable and flexible method for getting rid of heat buildup is to use a heat exchanger. Initially, the heat can be picked up inside the electronic package directly by

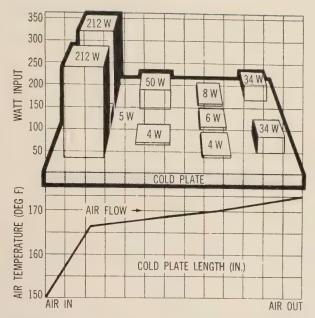
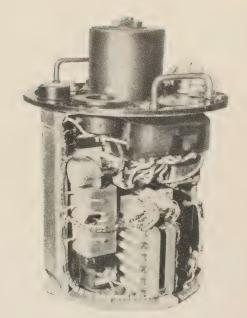


FIGURE 1: Center-mounted 13x10-in. cold plate dissipates 569 W. Air in is at 150 deg F; plate temperature is



173 deg F maximum. Assembly is sealed and pressurized for maximum reliability.

Table 1: Heat Concentrations

	AERODYNAMIC	ELECTRONIC				
Max. Airspeeds	Cooling Method	Power Density	Type of Cooling System			
Mach 1	ram air	0.15	natural cooling			
Mach 2	air-cycle systems	7	forced-air cooling			
Mach 2.5	evaporation heat sink	10	direct liquid cooling			
Mach 2.5+	insulation & isolation plus recirculated heat sink or transfer fluid	20	vaporization cooling			

conduction or indirectly by the recirculation of a gas (which may be air) or a liquid surrounding the electronic components. The heat exchanger then brings this heat in contact with a secondary transfer medium (again either a gas or a liquid) that is kept at a much lower temperature. From here, the heat is dumped either directly or indirectly into the final heat sink.

Can be integrated with assembly

Heat exchangers can be installed in a variety of places: in blower housings, in "black box" cabinet walls, in air ducts, or at remote points next to a convenient heat sink.

When compact installations are needed, the heat exchanger can be made a part of the electronic assembly. As such, it can serve either as the structural base of the chassis, with the electronic components mounted on one

side, or it can be center-mounted, with components fixed on top and bottom. In the example shown in *Figure 1*, the electronic assembly was sealed and pressurized for maximum reliability.

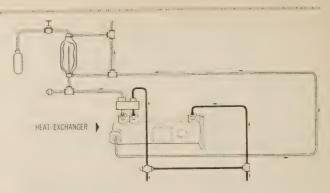
In installations of this type, the heat exchangers often are called "cold plates," since a cold gas or evaporating liquid is passed through finned passageways in the equipment chassis and practically all heat transfer is by conduction through fins and the metal chassis. In some cases, a small fan is used to keep the air moving over the tubes and surface fins and so speed up the heat transfer. The cold plate is readily adapted to such requirements as hermetic sealing, pressurization, structural strength, and the prevention of equipment contamination from coolants.

Heat exchangers of the air-air and gas-air types fundamentally rely on convection for the initial heat

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•	
Гуре	evaporative cooling system
iransfer me∜	oil
Heat sink	aqueous ammonia
Heat-dissipating capabilities	600 btu/min
Ambient temperatures	—65 to +200 deg F
Envelope	8.875x2.75x2.75 in
Dry weight	1.1 lb

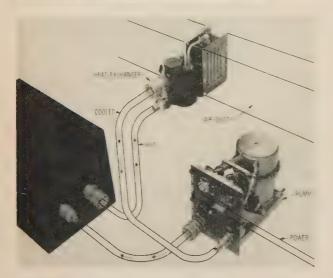
COOLING of the electronics compartment of a ramjet-powered missile operating at Mach 3.5 and 80,000 ft altitude. The cooling system includes pressure and temperature control valves, a positive expulsion tank, and system charging provisions. The heat exchanger is $10\frac{7}{8}$



in. long, 21/2 in. in diameter, and weighs 1.1 lb. This type of system develops heat transfer coefficients up to thirty times larger than any achieved in previous cooling designs. Evaporative fluid boil-off amounts to about 95-98 per cent.

air-liquid heat exchanger

Type



COOLING of bombing-navigation system of a bomber operating at near-sonic speed and 70,000 ft altitude. If the air inlet temperature at the cooler face does not ex-

Transfer medium	Coolanoi
Heat sink	cabin conditioning air
Heat-dissipating capabilities	350 W
Ambient temperatures	—65 to +212 deg F
Envelope of pump & accessories	5.75x7.85x9 in,
Envelope of cooler	203x8x6 in
Weight	9.312 lb
Required power	208-V, 3-phase, 4-wire, 400-cycle ac

ceed 131 deg F at sea level or zero degrees F at 70,000 ft, the coolant leaving the equipment will be held at a maximum of 212 deg F.

pickup inside the "black box". They use a fan-and-duct system to recirculate the internal air or gas through the heat exchanger. The electronic equipment usually is *not* mounted on the exchanger in this case.

Heat sink may be liquid or gas

In the mechanical-refrigerator type of cooling system, the recirculated refrigerant is the heat transfer medium. The heat sink can be either ambient air or any liquid or gas.

Liquids as heat transfer fluids have many important advantages. They can link up widely separated heat sources and remote heat sinks, and they require minimum power for high rate transfer of heat. Because heat exchangers using liquids need only small transfer lines and since only one-tenth as much volume as air-core types, they can be installed in crowded locations. Since valving is also lightweight, switching

to alternate heat sinks is simple, and prelaunch and flight cooling systems can be integrated. Some of the better heat transfer liquids are water, Coolanol 45 methanol, and ethylene-glycol.

Liquids of the expendable-evaporant type can be practical for high speed flight when they are discharged overboard as vapor. These liquids can be distributed to dispersed equipment through small lines from a central system.

Eliminating transfer heat gain

In very high temperature environments, transfer heat gain can be eliminated by using self-contained expendable-evaporant systems for each separate electronic system. In such a design, evaporants with different boiling points can be used to match different temperature limit requirements.

The main drawback of expendable liquid evaporants

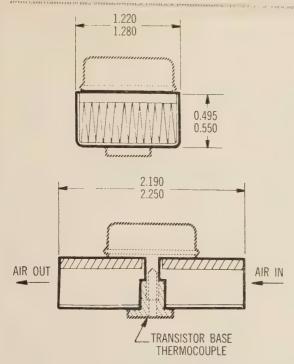
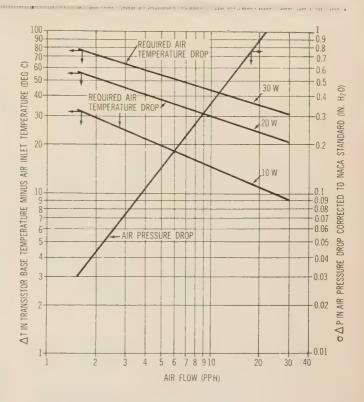


FIGURE 2: Single-transistor aluminum cold plate: air flow, seven pph; air pressure drop, 0.25 in.; temperature drop in plate, 1.5 deg C per watt; weight, one ounce.



TRANSISTOR cold plate performance.

is the weight of the evaporant that must be stored for use. This can be minimized, though, when the system uses several evaporants, each with a different boiling point.

Most transistors dissipate little heat of their own. However, they are affected by heat build-up from any adjacent heat-dissipating component or from aero-dynamic heating. To prevent derating, ambient conditions must be controlled within close limits. Excessive heat may be reduced or avoided by placing the transistors so that the cooling medium reaches them before it picks up heat from resistors or transformers in the system.

Transistors build up their own heat through internal power losses. These stem from high internal resistances and generate enough heat to affect transistor operation. This internal heat must be removed. The amount that can be removed depends on the construction of the transistor and on the ambient temperature.

In some types of transistors, cooling fins are provided in the external case. In others, the transistor is fastened to a heat-conducting body such as the chassis, a cold plate, or a heat exchanger.

Aluminum cold plates are proving highly successful in this construction. Many of them are designed for single-transistor installations (Fig. 2); others are designed for mounting as many as 30 or more transistors. When the transistors vary in power ratings from position to position, the cold plate fins are varied in configuration and density to provide the required heat dissipation pattern or curve.

In operation, internal heat from each transistor is

conducted through the mount into the fin area, which is cooled by forced air. This air can be ducted from a circulating cabin system, an air-cycle refrigeration system, a ram air supply, or any other suitable source.

The more critical requirements of missiles have resulted in advanced systems using such techniques as cryogenics, concurrent heat-mass transfer, evaporative cycles, and improved heat exchangers. Prelaunch cooling is becoming increasingly important. When it is the only requirement, individual items can be cooled internally with evaporants, or an external system can be used that disconnects upon launch. In air-launched missiles, the circulating coolant could be supplied by the carrier aircraft.

When the missile requires both prelaunch and flight cooling, liquids can be used very efficiently as recirculating heat transfer fluids. Many combinations of air, liquid, and evaporant prelaunch cooling can be combined with liquid and evaporant flight cooling.

More cooling of individual units

Among the many advanced cooling techniques (*Table II*), isolated and supplementary cooling of the individual electronic elements is increasing. In one notable case, heat from a transmitter tube is conducted to a flexible, liquid-cooled surface by circulating the fluid through a double-walled silicone rubber cooling jacket shaped to the tube's contours.

Internal chassis surfaces in some cases are directly cooled by liquid flowing through passages brazed di-

more on next page

Table II: COOLING FOR MISSILES

an an manana										
EQUIPMENT TYPE		MISSILE				GUIDANCE				
	Surface-Surface	Air-Surface	Air-Air	Surface-Air	ICBM	Drone	Radar	Internal	Infra-red	Radio
Cooling Systems				1						
Mechanical					•		•	Ì		•
Expendable	•	•			•					
Cyrogenic					•				•	
Heat Transport						•				
Evaporative	•			•		•				•
Heat Exchangers	1									
Liquid-Air	•	•		•	-	•	•	•		•
Ammonia-Glycol	•		-			1				
Evaporative		•								
Liquid-Liquid	•	•		•				•		
Liquid-Ammonia										
Liquid Oxygen							•			
Hot Gas-Nitrogen Tetroxide				•						
Ammonia-Air				•			•			
Cold Plate			•				•	•		

Prepared for Space/Aeronautics by Howard Otto, Design Engineer, United Aircraft Products

rectly to the chassis. This system is designed for forced liquid flow with or without evaporation. It can use water or any of its solutions as a coolant.

The same technique is also being applied with some high heat density modules. These are mounted on a common metal plate that is held against the cooled surface by spring-loaded tracks.

The lowest possible parts temperatures can be had in sealed units when a dielectric liquid is used internally to transfer heat from the parts to a heat-exchange surface. In comparison with internal forced air convection, heat transfer coefficients are increased by one magnitude when the fluid just flows and by two magnitudes when it boils and condenses. Optimum system temperatures, weights, and sizes are achieved when high vapor pressure dielectrics, such as fluorochemicals, are used.

Direct liquid cooling can also rely on capillary action, in which case fiberglass wicks are used, or on liquid jets. The wick method (with heat exchanger overhead) works evaporatively and is ideal for overheat control of isolated or dispersed packages of low height and small base area.

Enveloping screens are applied

Liquid-film cooling is possible with an internal circulating pump that deposits a film by jet action. A uniform film action can be gotten by enveloping the parts in metal or fiberglass screens.

In one design of this type, the jets are located in a manifold extending over the electronic assembly. The entire unit is enclosed in a pressurized cabinet, and a liquid-liquid heat exchanger forms the main chassis of the unit.

Closed-cycle evaporative cooling with fluorochemicals in a sealed assembly is another important method. The electronic components are completely sealed in coolant, and there is only a small gap between the liquid level and the enclosure top. Heat is carried off as the liquid vaporizes and condenses on the enclosure top. After it condenses on this cold surface, the liquid returns by gravity to the bath. This evaporative-gravity technique holds a lot of promise for electronic equipment that has been miniaturized to the point at which more conventional cooling methods are limited.

Recent work on concurrent heat and mass transfer in ultra high speed aircraft cooling shows we might get excellent results by using ram air and expendable coolants—even though the inlet air temperatures that are involved once were considered intolerable. The Peltier effect, or thermo-electric cooling, is also being studied—for cooling advanced spacecraft electronics. It appears that this method might prove useful for transistor cooling.—End

GAS-AIR heat exchanger (below) mounts on electronic chassis. Right: Compact mechanical refrigeration unit containing compressor, evaporator, air-moving devices, and controls weighs 26 lb.





Infrared missile homing

proves simplest, most accurate

Guidance for a homing missile consists of an autopilot and a target seeker. The seeker determines the target-missile relationship, solves the equations of relative motion, and generates the steering commands for the autopilot. Among the many types of seekers, infrared units have proved simplest and most accurate.

by Wesley J. Haywood, Jr., Manager,
Optics & Infrared Branch, Missile Systems Div.,
Raytheon Corp.*

THE HEART of an infrared guidance system is the detector, which converts photons of electromagnetic energy into electrons in an electric circuit. It uses either a direct energy exchange within the detector material, which frees bound electrons, or a resistance change in the material, which modulates a current flow. Semiconductors produce the first kind of response, photoresistors and bolometers exhibit the second kind. There is a net energy loss in both processes, since not all quanta are captured or used to produce signals.

A typical IR seeker system consists of a detector, an amplifier, and a computer in series. All three elements, naturally, have noise thresholds. In a well-designed system, the detector noise should be well above that produced by the associated electronics, so that you can make full use of detector sensitivity. A satisfactory noise level is not difficult to achieve with most currently available IR detectors. Some detectors, it's true, have very high or very low input impedances and thus are hard to work with.

The computer has to operate on the complex signal and determine line-of-sight angles and angular rates of rotation of that line in the chosen type of coordinate system. This task is relatively simple in theory,

* Missile Systems Div., Raytheon Mfg. Co., Waltham, Mass. A slightly different version of this article appeared in Raytheon's internal house organ, Electronic Progress, May-June '59.

but at the high speeds of actual missile operation, the necessary accuracy is quite difficult to achieve.

To simplify this discussion, let's assume our missile knows which way is "up," so that we can use simple Cartesian coordinates for our measurement. It is quite possible to solve all the problems for a missile that is free to roll on its own axis and therefore has no "up" reference, but the dynamics of the problem make for a complicated analysis.

The problem of sensing the direction in space of the target is one of determining the direction of arrival of electromagnetic energy, which can be done in many ways. The simplest is to expose a detector with a flat plane surface to the incident energy. If this detector is slowly rotated around two axes through the plane until the signal is a maximum around each axis, it will then be perpendicular to the direction of arrival of the incident energy.

Assuming the direction of arrival of the energy is perpendicular to the y-axis in the detector, which is then rotated 180 deg around the x-axis, then the contour of the output signal with respect to the angle of rotation will be as shown in Figure 1. If now the detector is oriented so that the signal with respect to rotation around the x-axis is a maximum and if then the detector is rotated around the y-axis, the response curve will be as shown again in Figure 1. The resultant output signal will always be a maximum when the

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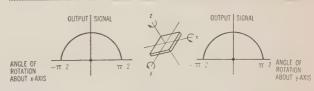


FIGURE 1: Direction of incident infrared energy relative to the rotation of the detector about the x-axis (left) and the y-axis (right).

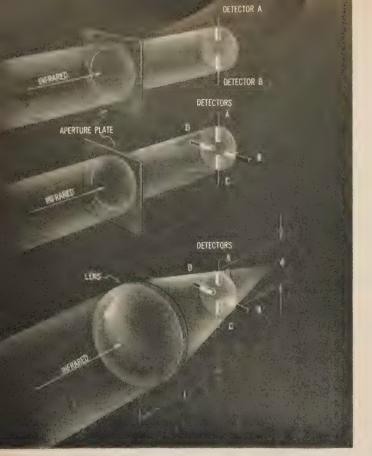


FIGURE 2: Determination of the motion of the line of sight between an infrared seeker and a source with two (A) and four (B and C) contiguous detectors.

plane of the detector is perpendicular to the direction of arrival of the energy.

This very simple directional device is, of course, very insensitive to change near the maxima. It is most sensitive near $\pm \pi/2$, where the response is quite small.

Figure 2 shows a simpler method that uses more than one detector. If the pencil beam of energy divides equally between the two detectors, the output signals from each will be equal. On the other hand, if the line of sight to the target rotates slightly so that one of the detectors receives more of the incident energy than the other, then the output signals are unbalanced. The amount of imbalance will be a function of the departure of the direction of the line of sight from zero incidence.

Four detectors give two signals

This technique can be extended to four detectors (Fig. 2), which make two signals available to the designer—one for departure of the line of sight in the x-direction and one for departure in the y-direction.

The sensitivity of the scheme shown in Figure 2 is something less than the maximum sensitivity of the detectors, for there must be a portion of each detector that does not receive energy if a change is to be sensed.

As a further refinement, a simple optical collecting system can be placed in front of the detectors (Fig. 2). The total lens area for reception of incident energy is considerably larger now than it was with the four detectors. Since all of the incident flux on the left-hand surface of the collecting lens is focused on the

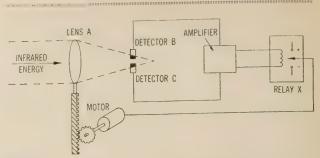


FIGURE 3: In a simple optical tracker, infrared energy is focused through lens A on detectors B and C. The up-down motion of the line of sight causes the cells to generate larger or smaller signals. These unbalanced signals are amplified and actuate a reversing relay.

circle incident at the four detectors, the flux density on the detectors is increased. If you select the right lens material and detector shapes and dispose of the detectors properly, you can build quite a satisfactory directional sensing system using the five elements shown in Figure 2.

However, there is a price to be paid for the optical gain in our simple systems. In optics it is roughly true that the product of the gain and the field of view is a constant, just as the gain-bandwidth product is constant in an electronic system. The simple directional scheme of $Figure\ 1$ has an extremely wide field of view—about π steradians. It also has a low gain, in the sense that the detector works unaided to collect energy. The simple combination of an optical collecting system and IR detectors of $Figure\ 2$, on the other hand, has a gain (K) given by:

(1)
$$K = (D^{2}\pi/4) / (d^{2}\pi/4) = D^{2}/d^{2},$$

where D is the lens diameter and d the diameter of the focal circle. In other words, here the optical gain is equal to the surface area of the lens divided by the sum of the useful areas of the detectors. The field of view $(\theta, \text{ in radians})$ of this system is given by:

(2)
$$\theta = 2 \tan^{-1} [(d/2)/f],$$

where $\theta = d/f$ for small angles and f is the focal distance.

As the field of view for small fields is approximately given by the image size divided by focal length, it is the angle subtended by the detectors at the lens. Note also that an increase in gain obtained by decreasing the size of the detectors decreases the field of view, too.

Unfortunately, the sensitivity of detectors is not independent of physical size. If $Equation\ 1$ is multiplied by $Equation\ 2$, we can see that the squared gain-field-ofview product is in fact a constant (lens area divided by its focal length squared) and equals one over the F-number (focal ratio) of the system:

$$C = \theta^2 D^2 / d^2 = D^2 / f^2 = 1 / F^2$$

where C is a constant. Since it is desirable to maximize the gain and have a field of view of some moderate size (as required by tactical situation) it seems best to make F-number as small as possible.

The intensity of the signal varies with changes in direction of the line of sight. Any IR missile directional system using these variations, however, also is affected by the change in intensity produced by the decreasing range as the missile homes on its target. To resolve the two rates of change, they must be separated in the

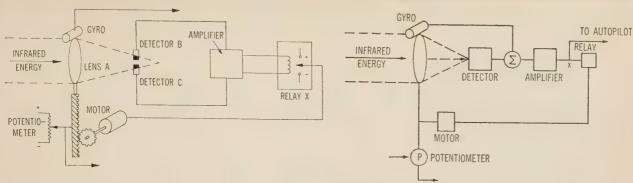


FIGURE 4: Refinement of the basic tracking loop of Figure 3.

enamentation and a second and a

FIGURE 5: In a further refinement, the gyro is coupled to the physical position of the lens.

frequency spectrum. One way of doing this is to make the amplitude change due to change in line of sight be very much faster than that produced by closure.

All missiles that use variation in intensity to detect directional changes come up against this problem. Its solution requires careful analytical study of the kinematics of the tactical situation and a careful analytical design of the dynamics of target-seeker tracking.

The simple optical systems and detection schemes we have covered so far all suffer from one fault: the detector must be in the field of view for the system to give an output that can be used to describe the position and motion of the target. Since the field of view of practical systems is only on the order of a couple of degrees in width and the target may occupy any posini space, some automatic system has to be used to keep the seeker pointed in the direction of the target.

One method of self-tracking is to analyze the detector output, determine the direction to the target, and use the resulting signal, which is proportional to direction, to drive a servomechanism to rotate the optical head to the correct position.

Figure 3 shows a simple self-tracker. Lens A focuses energy on cells B and C. The motion of the line of sight in the up-down direction causes a greater or smaller signal to be generated by each of the cells. Applied to an amplifier, these unbalanced signals actuate a reversing relay to drive the motor-gear-lens linkage. This servo loop can track moving targets over moderate changes of the line of sight in a single plane. For two-axis tracking, two such loops have to be used.

Fast response in the key problem

The response of the closed-loop system must be fast enough to keep a moving target in the field of view. This one requirement is the key design problem with IR homing target seekers.

By making the IR tracker a closed-loop device, we have substituted changes in the position of the principal lens for changes in the signal output of the director as the direction of the line of sight changes. The mechanical motion of the lens corresponds to the angular position of the line of sight and to its angular rate of change in space.

The position of the lens is easily sensed, but it is difficult to sense the lens's rate of motion. Figure 4 shows one way of sensing physical position. A voltage

proportional to the position of a rack appears on a potentiometer wiper arm.

To get the rate of motion, we could theoretically differentiate this voltage, but the inherent noise of potentiometers rules out this approach. For this reason as well as several others connected with the kinematics of high performance missile design, it's better to mount a small gyro on top of the lens (Fig. 4). The signal from this gyro will be proportional to the motion of the head while a target is being tracked. Since gyros can sense motion only around a single axis, two are needed to drive the lens around two axes. They would be mounted orthogonally.

Such as system would work well with a target that produces a signal above the system noise. However, since the loop is open, the system is free to take up any position. Any noise in the system, for example, might actuate the relay and drive the motor to one stop.

To avoid such effects, we can make a second loop by mechanically coupling the physical position of the lens to a gyro (Fig. 5). Now both the velocity and the position of the lens will be zero when there is no IR signal.

Another advantage of the two-loop arrangement is that the position of the lens in inertial coordinates has been reduced to a constant. If the lens attached to the missile were to take up a rotation around one missile coordinate as the missile accelerates in a given direction, this would constitute a motion of the lens in inertial coordinates. The gyro would sense such a motion, however, and would generate a signal strong enough to control the motor and rotate the lens in the opposite direction. In effect, the missile would be rotating, but not the lens. For motions of the missile in inertial space, the direction of the line of sight would remain unaffected and the primary lens position-controlled so as to make it look along the line of sight regardless of motions of the missile axis.

A further advantage of the second loop is that, in the presence of an IR signal, the rate at which the head tracks the target is now proportional to the magnitude of the target displacement from the boresight. This tends to make the head track more smoothly and to produce better data.

The output of the amplifier (taken off at point X in Figure 5) now contains both the position and the velocity data of the target in missile coordinates. This signal is suitable for feeding to the autopilot.—End

DONNER helps it think ...

One day soon the U. S. Navy will file a report more fantastic than any sea serpent tale we've ever heard. This will be the launching of the Navy's spectacular Polaris missile from a submerged nuclear submarine. Advanced testing is underway; the Polaris will be ready for the fleet in 1960.

Smaller and lighter than other intermediate range ballistic missiles, this formidable Lockheed developed weapon features much that is new in advanced electronics. It even "thinks" for itself.

One such "think" device aboard the Polaris is a system developed by Donner Scientific Company using as a base a standard Model 4310 Accelerometer. The system monitors flight performance like a policeman directing traffic. If, for example, in the initial portion of the flight, the missile does not achieve sufficient velocity by a pre-determined time, the Donner system aborts the flight. The missile gets the go-ahead only as programmed.

Donner's role in the Polaris project represents another basic contribution from an engineering team which specializes in accurate systems, interlocking time, acceleration, velocity and other inputs designed to meet customers' requirements.

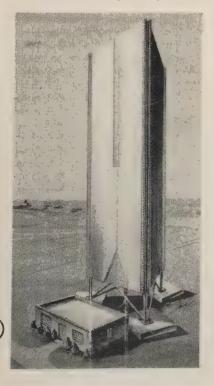
Donner welcomes your inquiries concerning the company's capabilities in this and related fields.



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HEIGHT FINDER SIDE ASR ANTENNA CANCE ANTENNA RECEIVER 132 CHANNELS 132 AZ, COINCIDENCE SIGNALS PARALLAX COMPUTER BEAM DISTRIBUTION SELECTOR MATRIX CODER-DECODER DATA LINK ΦR Φ', R' 'A'' HEIGHT "B" HEIGHT SYNCH COMPUTER COMPUTER $h = R \sin \Phi + \Delta h$ $h'=R'\sin\varphi'+\Delta h'$ ∬ I h PULSE ANALOG ALTITUDE DISPLAY TRACKER **PROCESSER**

FUNCTIONAL—Any of 132 lines from AHSR (66 each from even- and odd-numbered arrays) may hold target. Parallax computer corrects for



relative az-el errors, time-delays AHSR inputs as needed, gives corrected range for height computation. Beam selector acts as difference comparator. Height resolution is one bandwidth. Sidelobes cancel by comparison with omni antenna. With single target, matrix simply forwards 132 lines. For two targets, it splits them-132 each to target A and target B channels. The 264 are coded into two 12-group sets for transmission over 23 frequencies (two adjacent ones at a time) to height computers. Here synch triggers sweep generators, one for each AHSR beam. Linear altitude sweep is a function of slant range (R), elevation angle (ø), and earth's curvature correction (Δh). The target on one of the sweeps triggers a one-microsecondwide gate generator whose recovery time is less than ASR pulsewidth. Output is thus a pulse whose amplitude is an analog of target altitude.

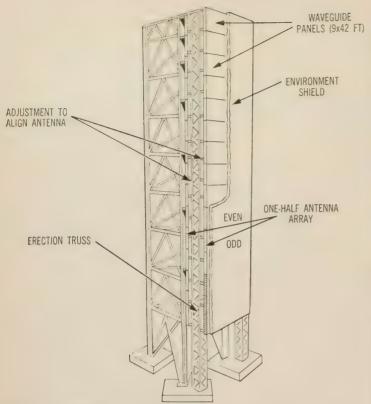
design

by Bernard Kovit
Associate Electronics Editor

Passive height finder for 3D traffic control

AN EXPERIMENTAL S-band height finder (AHSR-1) designed by The W. L. Maxson Corp., New York, N.Y., may meet FAA's long-sought goal of a 360deg, 3D radar display of planes entering or traversing a terminal area. Maxson's system is completely passive and mounts three fixed antenna arrays on a 160-ft triangular steel tower. An array consisting of 1056 antenna elements - each sensitive to a particular angular direction in space — fixed-scans targets illuminated by an ASR. Height computers, with R and az from the ASR and elevation angle from the height antenna, figure target altitude to ±500 ft at maximum range (50 miles). System must resolve two targets in same az-range capsule separated by 1000 ft. FAA's main reasons for going with Maxson's design were minimum maintenance needs (no active electronics or moving structures) and the fact that the AHSR-1 dovetails with, but doesn't overlap, the functions of existing 2D radars.

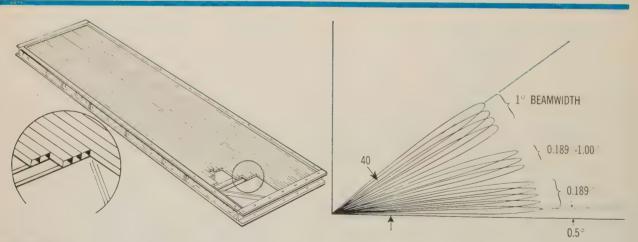
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S-BAND ANTENNA—The horizontal WG elements mount in 15 panels on each side of tower. Coupled with them are 132 vertical WG feed lines. Each full antenna array is made up of half-arrays, one with 528 even-number-only elements, the other with 528 odd. Each half-array's apertures "scan" a 60-deg-az, 40-deg-el region. L-band beacon antenna with dipole arrays follows design of main antenna, mounts behind S-band panels at each corner.

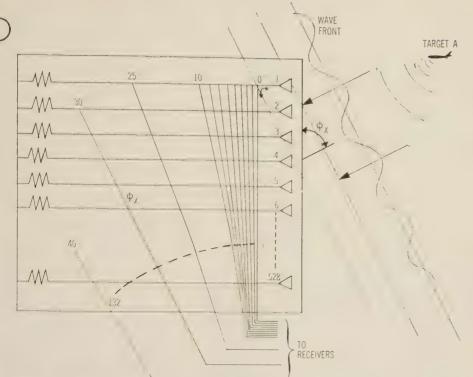
FAA Specs for Height Finder

- · Frequency: S-band
- Type: receiving system only for use with ASR-2, -3, and -4, and CPN-18 surveillance radars; L-band receiver is also provided.
- Slant Range: 50nm maximum
- Angular Coverage: Azimuth, 360 deg; elevation, 0.5-40 deg
- Accuracy: ±500 ft (at maximum range)
- Number of Targets: maximum of 20 in same azimuth capsule, two in same azimuth and range capsule.
- Two-Target Resolution: resolve two targets in same az-range sector separated in altitude by as little as 1000 ft
- Data Output: pulse amplitude analog
- \bullet Altitude pulsewidth: 1 ± 0.2 usec, will have rise and fall times equal to or better than those of ASR
- PRF range: 300-2000 cps
- Future altitude capability: system output capable of expansion to 100,000 ft maximum height when radar inputs to this altitude become available.



BREADBOARD PANEL—To prove the feasibility of constructing the huge, multi-element antenna panels, Maxson had a breadboard model built (left). Magnified portion shows horizontal waveguides mounted next to each other on rigid structural frame. In actual antenna, 15 of the 9x42-ft panels will be used on each of three sides. Attached directly to and across the panel will be 132 vertical waveguide feedlines. These will couple energy

down to the receiver system at the base of the tower. Right: In radiation pattern, elevation angle between 0.5 and 40 deg above horizon is covered by 132 beams, each monitored by a receiver. S-band antenna has narrower beamwidths for maximum range (50 miles), increasing to over one degree at higher elevation angles, at which aircraft altitude limits greatly decrease the range.



design digest

DIRECTIONAL coupling arrangement is so aligned as to be most sensitive to a signal of a given phase in the horizontal element. This holds for all couplers located along any one of the 132 vertical feeds.

HOW ANTENNA WORKS-Wave front excites all 528 antenna elements, each of whose apertures receives energy at a different phase, in linear progression. As energy passes along horizontal WG to verticals, each directional coupler that is passed samples it. As energy goes down verticals, a fixed delay is applied, so that at each coupler, energy is in phase and adds. Thus in the proper feed (corresponding to angle ϕ_x) all signals add. Receiver channel ϕ_x therefore carries energy of a greater magnitude than any other.

 p,θ

TIME BASE

HORN DIRECTIONAL' COUPLING **VERTICAL** FEED 50-MILE RANGE



120 DEG . ANTENNA III 120 DEG 120 DEG

AZIMUTH COVERAGE-RF inputs to 132 re-

3D DISPLAY-PPI tube's radius is split (80% for 2D, 20% for height). Comparator circuit monitors range sweep voltages, starts height sweep when voltage equals r1. At this time, video input is switched to height video. By controlling the time base, height sweep can be used to present 40,000-ft coverage or any 10,000-ft layer.

PPI DISPLAY AREA

HEIGHT DISPLAY AREA

BASE REFERENCE OR SWITCH OVER BOUNDARY

> ceivers are switched to each bay in synch with ASR rotation. AHSR "scans" sectors as they are illuminated.



Pages from an Engineer's Notebook

Normalized Doppler shift curves

by Julius J. Hupert, Associate Professor of Physics, De Paul University*

CERTAIN missile scoring devices use the Doppler shift to tell how close the missile comes to its target. These devices monitor changes in the frequency of RF signals transmitted by the missile as a function of time.

Both the Doppler shift curve and its time derivative can be conveniently normalized (Fig. 2):

$$F = F_0 - (F_0/c) (\overrightarrow{dr}/dt),$$

$$|\overrightarrow{r}| = y_0 1 / \{cos[arctan(V_1 t/y_0)]\},$$

$$\overrightarrow{dr}/dt = V_1 sin[arctan(V_1 t/y_0)].$$

De Paul University, 2322 N. Kenmore, Chicago, Ill. These curves were used by Prof. Hubert in consultative work for ARF Products, of River Forest, Ill.

The Doppler shift is:

 $f_D = -F_0(V_i/c)sin[arctan(V_it/y_0)].$ The time derivative of f_D is:

$$\dot{f}_D = \frac{df_D}{dt} = -\left(\frac{V_1 * F_0}{c y_0}\right)$$
$$\left(\frac{cos[arctan(V_1 t/y_0)]}{1 + (V_1 t/y_0)^*}\right)$$

The maximum value of the time derivative is:

$$|f_D|_{max} = [V_1^{\varrho}/(cy_0)]F_{00}$$

If we choose the ordinates so that t=0 at the moment of minimum distance (y_o) , then we can conveniently construct a normalized "universal" plot of f_D and \dot{f}_D by

using the following modified coordinates: abscissa (common) is $x = (V_1/y_0)t$, ordinate for normalized f_D is $\bar{f_D} = function$ (x) where $\bar{f_D} = f_D/[(V_1/c)F_0]$, ordinate for normalized

malized f_D is $\overline{f}_D = function(x)$ where

$$\overline{f}_D = f_D/\{V_1^2/[(cy_0)F_0]\}.$$

Figure 1 shows the normalized curves. For x=1, the absolute value of the Doppler shift is 0.707 of the maximum value, and, at that point:

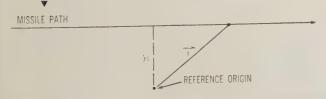
$$|f_D|/|f_D|_{max} = 1/(\sqrt{2}).$$

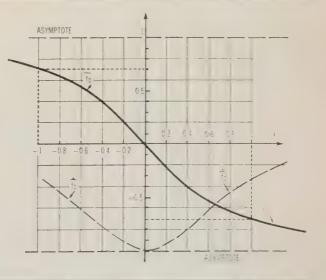
This relationship occurs at $x=0.5$.

The curve $|\vec{f}_D| = function \ of \ (x)$, which could be generated by anamore on next page

FIGURE 1: Normalized curves, where $x = (\bigvee_1/y_o) t$, $\overline{f}_D = f_D / [(\bigvee_1/c) F_o]$, and $\dot{\overline{f}}_D = \dot{f}_D / [(\bigvee_1^2/cy_o) F_o]$.

FIGURE 2: Problem geometry, where relative velocity (V_1) is constant, y_{\circ} is minimum distance, and F_{\bullet} frequency of the transmitter in the missile.







liquid cooling units for 50 to 50,000 watts dissipation FASTERN 100 SKIFF STREET HAMDEN 14, CONN

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PIONEERS OF THE THERMAL FRONTIER

log devices, since there is a maximum at t=0, may prove useful in pinpointing the moment of minimum distance.-End

Radar Blips

ининизменициянини полицияния принципальный п

A RADAR-LIKE device recently bought by Singer Military Products can detect movements from a few inches to several thousand feet away. Swami (standing-wave area indicator) uses a small UHF transmitter pulsed at a low rep rate. The pattern under surveillance repends on the antenna type—it's either omnidirectional or directional.

Persons or objects entering the monitored area disturb the RF propagation pattern and cause a change in the transmitter's rep rate. The change is detected by a simple circuit that actuates a warning light.

Swami, says Singer, could be used, for example, to guard nuclear test ranges.

ULTRA-PRECISE tracking radar for the Atlas ICBM is being made at GE's Ordnance Plant a secret plant in Massachusetts' Berkshire Hills. Resolution of the system will be 100 ft at 2500 miles, claims GE.

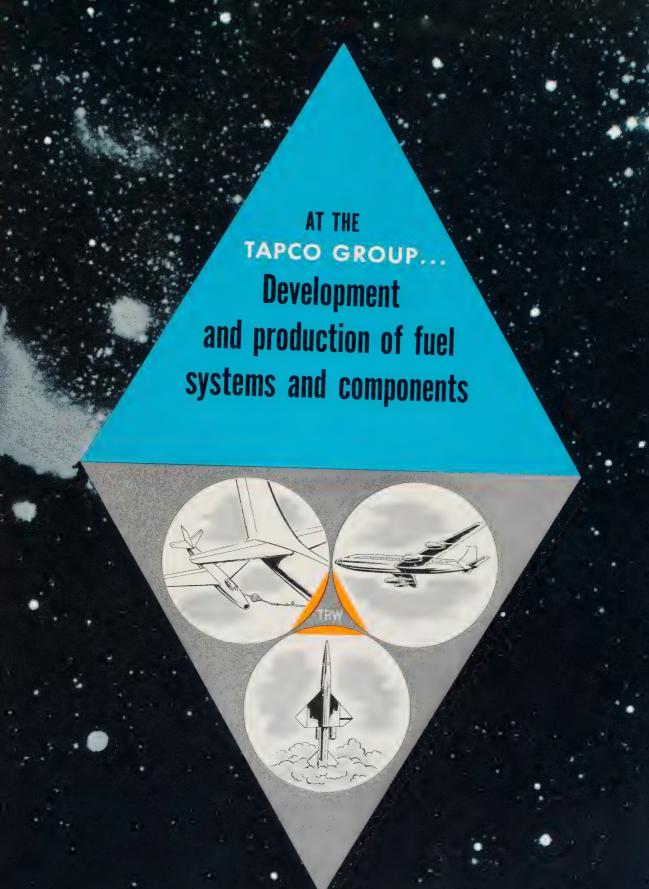
To get the necesary precision, GE had to use watchmaker tolerances. For example, the tolerance on a 2½-in, bearing race in the azimuth pedestal is 50 millionths of an inch. An eight-foot-long, 21/2-in.diameter elevation shaft had to be held to 2x10-4 in. in length and 10⁻⁴ in. in concentricity and roundness.

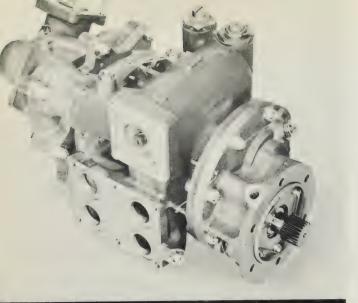
NEW AN/APS-99 airborne radar. in development at Maxson, will use the company's Fastar concept. It is sponsored by ARDC WADC under an \$800,000 contract. The radar will provide rapid information needed for mapping and bombing operations.

FIRST AN/APS-80 airborne search radar was delivered to BuAer for test and evaluation by Texas Instrument's Apparatus Div. Initially, the radar will be used by antisub aircraft.

PICTURE CREDITS: Cover. Bp. 42-45-8/A; pp. 54-56-

Write 257 Reader Service Card SPACE/AERONAUTICS





TAPCO designed and produced engine-driven combination main-and-afterburner fuel pump now providing thousands of hours of trouble-free service in several current models of production fighter aircraft.



Plug-in type electric motor driven submerged booster pump, designed and produced by TAPCO for a major American jet airliner, facilitates easy removal for routine inspection without draining fuel tanks.



This turbine-driven water injection thrust-augmentation pump and controls combines three TAPCO Group capabilities: the experience and facilities to design, produce, and test the pump, electronic controls and turbine entirely within the TAPCO organization.

FROM THE TAPCO GROUP...

Pumps, Controls, and Accessories to handle any fuel, any fuel situation

Over 1,100,000 pumps delivered...twenty years of experience that began in 1939...10,000 people.. 3,000,000 square feet of research and production area ... these are some of the reasons the Tapco Group is the leading developer and manufacturer of all types of aircraft and missile pumps, controls, fuel valves, and turbine-driven pumps and accessories.

Tapco pumps have been developed to meet severes conditions of altitude, rate of climb, pressure, attitude G-factors, and fuel chemistry. Tapco-designed models include vane- and gear-type main engine fuel pumps fuel transfer and vapor separating booster pumps, thrust augmentation pumps, turbo-pumps, combination main and-afterburner pumps.

New Tapco impeller designs, improved seals and internal passages give Tapco pumps maximum efficiency and the ability to perform dependably under severes flight and temperature conditions, while pumping any of the approved liquid fuels and supplements. A feature of Tapco booster pumps is high vapor-elimination capability, which eliminates vapor-lock in the fuel system.

Other fuel-system components and accessories developed in producing homogeneous, single-source TAPC fuel systems include control valves, air turbine drive for pumps, quick-disconnect couplings, flow-equalize valves, and in-flight refueling systems.

For your aircraft or missile contract, let us supply you with a *complete fuel system* designed, built, and full service-tested by the leader and largest manufacturer of fuel pumps and systems...the TAPCO Group.

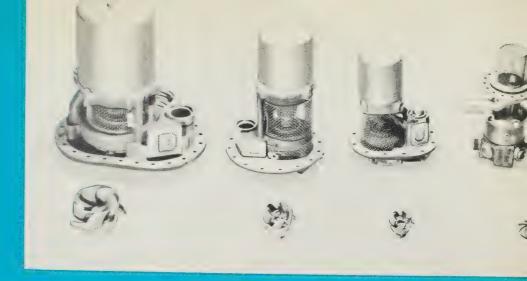


TAPCO GROUP

Thompson Ramo Wooldridge Inc.

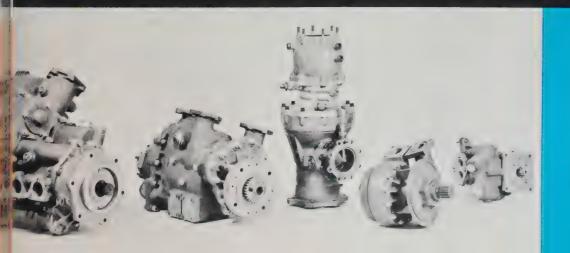
CLEVELAND 17, OHIO

DESIGNERS AND MANUFACTURERS OF SYSTEMS, SUBSYSTEM AND COMPONENTS FOR THE AIRCRAFT, MISSILE, ORDNANC ELECTRONIC, AND NUCLEAR INDUSTRIES Over 20 years of booster pump experience is illustrated by representative models in this and the center photo. Early World War II DC electric motordriven model, at right, had a capacity of 3 gpm at altitudes to 35,000 feet. Later models, at left and below, can handle up to 250 gpm at 70,000 feet. The impellers shown indicate the results of TAPCO research to provide good vapor elimination and pumping ability as requirements increased.





The broad variety of booster pumps now in production at TAPCO includes these AC electric and hydraulic motor-driven units for helicopters and small aircraft, as well as special designs for unusual negative G conditions for high performance fighter aircraft. Capacities range from 2 gpm to 250 gpm.



Engine driven gear, centrifugal and regenerative-type fuel and water injection pumps for military and commercial aircraft are designed, produced and tested in the TAPCO Group's facilities. Capacities range from 2 gpm to 220 gpm, with discharge pressures as high as 1200 psi and suction specific speeds as high as 30,000 rpm.

IN THE TAPCO GROUP...

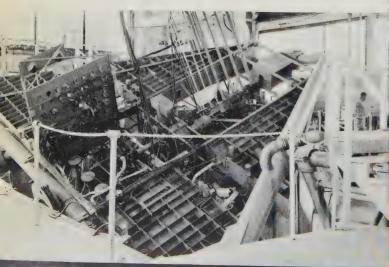
Complete research and test facilities...plus supporting services

For over 20 years, the development of new fuel system principles and the design of pumps and components to utilize these principles have been a major area of investigation for the Tapco Group research department. Just as the seemingly insurmountable problem of getting cargo aircraft over the Himalaya mountains was solved by Tapco-pioneered booster pumps during World War II, Tapco continues to pioneer the state of the art in fuel system development.

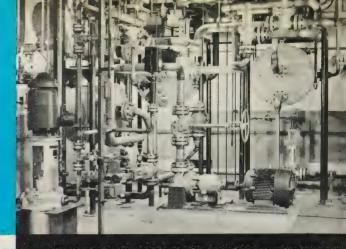
Today, more than 1000 experienced men and women using 7 Tapco fuel labs are investigating and developing techniques to power tomorrow's flight vehicles of all types. They have worked with high energy fuels such as boron, slurries and monopropellant fuels such as ethylene oxide, UDMH and normal propylnitrate. Extensive work has been done with anhydrous hydrazine. Experience is being accumulated with the new fuels for advanced spacecraft, such as liquid hydrogen.

To assure proper support for fuel system and component contracts, a highly-skilled field service organization is maintained, and spare parts singly or in kits are available to meet your requirements.

Let us have a TAPCO Group sales engineer discuss *complete* fuel systems, pumps, controls, and valves with you soon.



High performance fighter aircraft fuel system simulated by this complete mockup at another TAPCO facility saved hundreds of expensive flight test hours.



Hot-fuel test lab at TAPCO, shown only in part here, can test fuel pumps under ambient temperature conditions as high a 750°F, circulating up to 500 gpm of fuel at 550°F at 1500 psi Pump-driver speeds up to 28,000 rpm are available. These conditions can be cycled for high Mach number flight schedules



Complete missile fuel system mockup at a TAPCO laborator simulates missile flight conditions for pre-flight checkout a the fuel system.

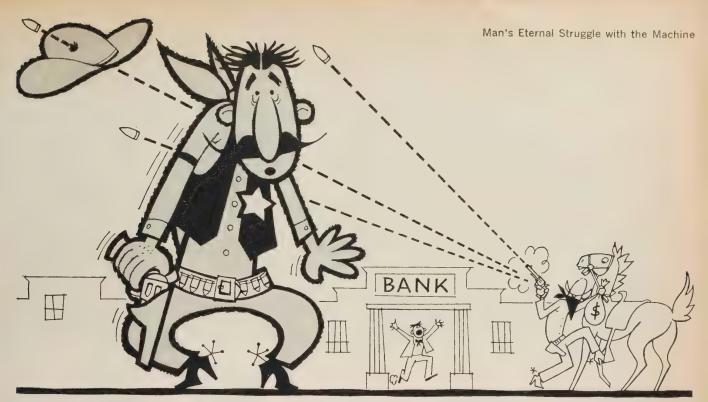


TAPCO GROUE

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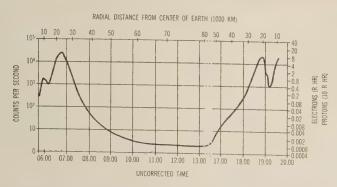


FIGURE 1: Radiation data obtained from Pioneer III's instruments on Dec. 6, 1958.

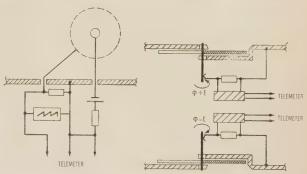


FIGURE 2: Sputnik's ion trap (left) and apparatus for measuring electrostatic fields (right).

How far are we on

space instrumentation?

With almost two years of space flight behind us, it's time to review what we've been able to achieve in the way of designing the instruments that will give us the data we need for more ambitious astronautic ventures.

by Ernst Stuhlinger, Director, Research Projects Laboratory, Development Operations Div., Army Ballistic Missile Agency*

DEVELOPMENT work on instruments for our first space probes actually began long before the development of large missiles. Immediately after World War II, a high altitude research project was organized at White Sands (N. M.) Proving Ground, first with old V-2 rockets and later with Aerobees, Vikings, and Corporals. Cosmic-ray counters, photocells, pressure and density meters, ion chambers, and even monkeys were rocketed to altitudes that, for all practical purposes, belongs to outer space.

When our first satellites were instrumented, they

profited greatly from this early high altitude research. Still, today's space instruments scarcely resemble their predecessors of the White Sands days. For one thing, semiconductors have come of age in the meantime and now set the design of nearly every space package. Today a complete multi-stage amplifier takes up less space than an electron tube did in 1946.

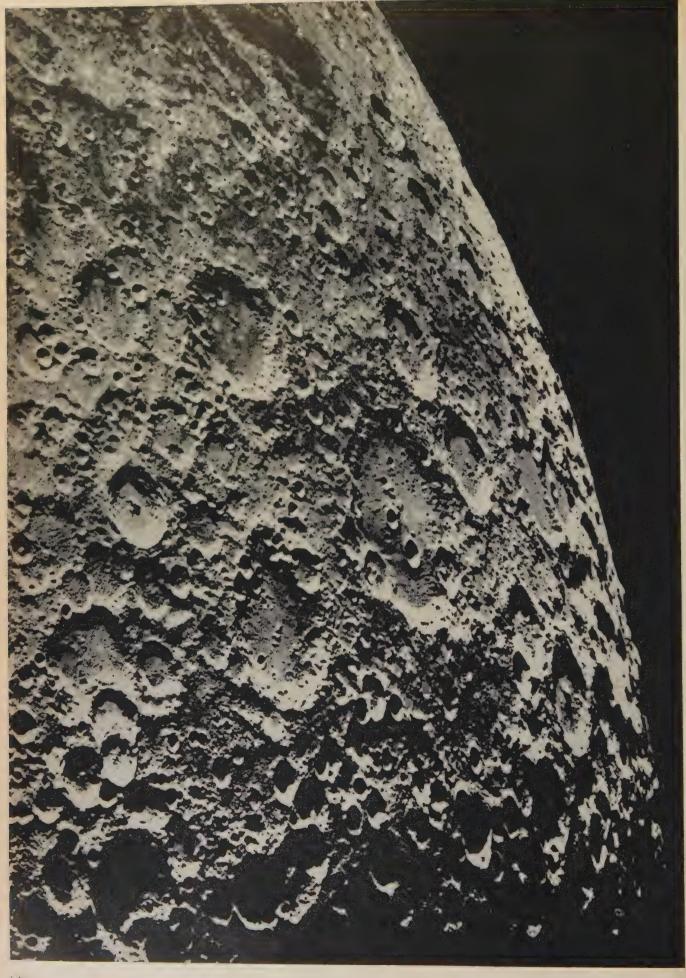
The instruments of the Explorer and Vanguard satellites are quite well known, as are their discoveries and other achievements: the great radiation belts (Fig. 1), the more accurate definition of the flatness of the earth (1/298.3 instead of 1/297), the earth's pear shape. more accurate data on atmospheric density at high altitudes (Fig. 3), and a few data on the frequency of meteorite impacts (Fig. 2).

An outstanding achievement is the long life of the solar-powered transmitter in Vanguard I. Despite exposure to high intensity radiation in the Van Allen belt. temperature variations, and the ravages of time itself. the little circuit has been operating for over a year now. dispelling many of the doubts about the performance of electronics in space.

Generally speaking, satellite instruments are designed

more on page 149

*Army Ballistic Missile Agency, Redstone Arsenal, Huntsville, Ala. This article is based largely on a paper given at a CalTech symposium on March 19.



THE MILITARY REQUIREMENTS

FOR

MOON BASE

This is the title of one of four major space proposals developed by Martin for the military and astroscientific branches of our Government. The importance of this proposal is two-fold: the inevitability of an actual moon base program by this country within the next 5 years, and; the fact that we could and can undertake such a project nownot in theory but in "hard" engineering design. For Martin's eight divisions add up to one of the top capabilities in the free world for man's first ventures in space-planetary exploration.



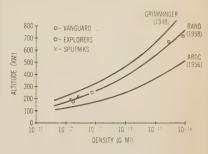


FIGURE 3: Satellite and probe data on atmospheric density vs altitude.

to collect data on three subjects: force fields, electromagnetic radiations, and corpuscles. Future satellites will add a fourth objective—pictorial recording of the earth and of celestial bodies. Indirectly, all these experiments provide us with data on power supply requirements and on the operation of instruments in space environments.

Table I lists the instrumentation aboard satellites launched during 1958. Some of the Sputnik experiments deserve special consideration, particularly (1) the ion traps shielded against electrons and negative ions, so that only positive ions reach the collecting electrode, and (2) the electrostatic field measurement by rotating shields to determine the field strength in space and the voltage to which the satellite is charged (Fig. 2).

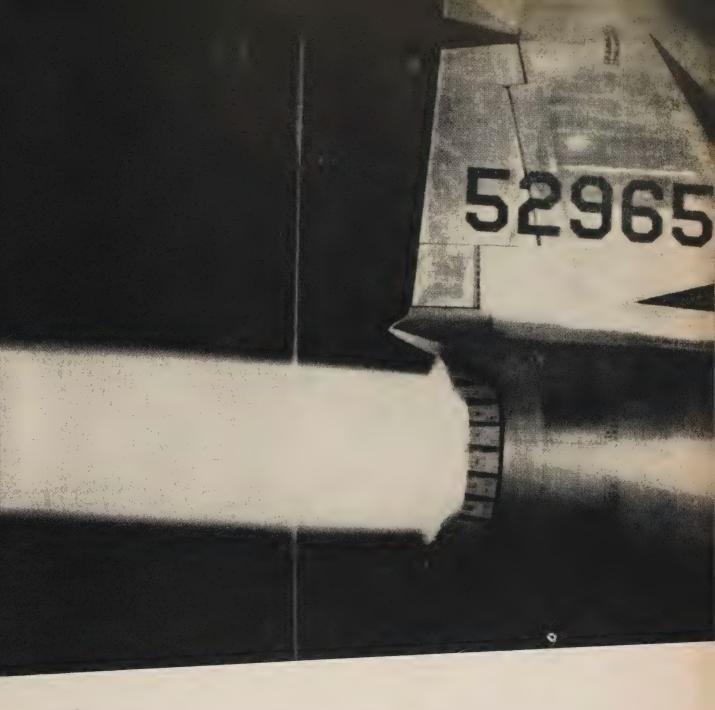
The data obtained in these two experiments showed the density of positive ions at 800 km altitude to be 1.8x10⁵ per cm³. The satellite was charged to —6.4 V, and the electron temperature was 15,000 deg K. At 242 km, these values changed to 5.2x10⁵ ions per cm³. —2 V, and 7000 deg K. Electrons and ions were clearly not in thermodynamic equilibrium, possibly because of an acceleration of the electrons as a result of variations in the earth's magnetic field.

A small, tube-shaped mass spectrometer was used to scoop up ions and pass them through a series of varying electric fields. At any given moment, only ions of a given charge-mass ratio could reach the collector electrode.

The earth's magnetic field was measured with a flux-gate magnetometer. The instrument controlled its own orientation so that it constantly measured the maxi-

more on page 152





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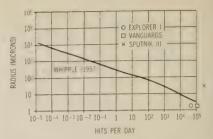


FIGURE 4: Instrument data on meteorite collisions with a spherical satellite of three meters diameter in the vicinity of earth.

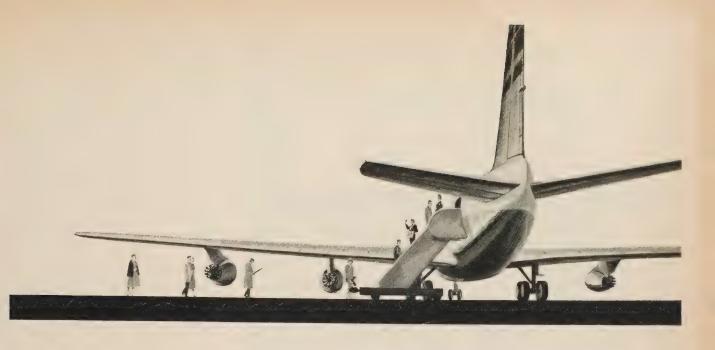
mum field vector. A pickup between this orientation and the satellite provided the attitude and tumbling mode of the sphere. Heavy cosmic particles were detected by a Cerenkov counter, fast electrons by a fluorescent screen with multiplier, Internal temperature was controlled by forced circulation of nitrogen between the interior and the surface-louvered heat exchange elements.

Telemetering systems reached a very advanced state. Yet, even with considerable weight and space allotted to data transmission, certain satellite experiments will be valueless unless at least part of the instrument package is recovered. Photographic emulsion plates, for instance, showing the tracks and nuclear explosions caused by cosmic particle bombardment must be studied microscopically by a human interpreter. Also, data from high resolution photo-telescopy should be preserved from the unavoidable degradation of TV transmission. Animal experiments should include extended periods of ground observation following exposure to space conditions. We may expect, therefore, that recovery packages will be a major requirement in our future explorations of space. Certainly they are a must in the design of manned satellites.

Whether or not the moon has a magnetic field will be determined when we are able to guide a space probe to the moon's vicinity. Perhaps the best way to find out would be to instrument the probe to search for a radiation belt, since even very weak fields trap electrons whose concentration can be recorded with a Geiger counter.

TV cameras will take close-ups of the front and rear sides of the

more on page 154



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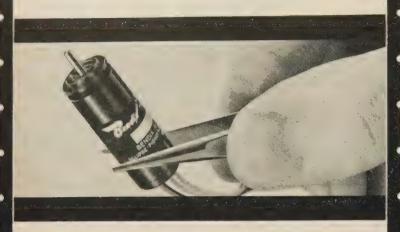


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moon. The picture signals will be stored on tape to be transmitted to earth later at a low rate (to save power). The size of the camera should pose no problem — units weighing only a few pounds are readily available. Their resolution is about 1000 lines per frame (as against the 500-line resolution of commercial TV units). This resolution is practically independent of tube size, being determined by the collimation of an electron beam and the precision of the electron optics.

Because of the guidance problems, we may expect the solar probe to precede the close lunar probe. It is easier to approach the sun on a solar ellipse, though the velocity requirements would be twice as high as for a lunar shot. The solar probe would carry instruments for detecting protons and electrons, gamma and X-rays, spectral lines like the Lyman-alpha line of hydrogen, and even shorter ultraviolet rays. It would also carry a magnetometer and a powerful transmitter to cover a distance on the order of 100 million miles. Solar cells will probably be used.

Both the Explorers' Microlock and Vanguard's Minitrack systems covered a distance of some 3000 miles with a radiated power of about one mw. This signal carried a very limited amount of telemetered information. If we tried to use the same system to cover 100 million miles, the necessary transmitter power would be 900 kw.

Pioneer IV, which carried a 160-mw transmitter, could have been tracked with an 84-ft dish over 700,000 miles had its batteries lasted long enough. This system would need a transmitter power of three kw for a distance of 100 million miles. Such performance supports the idea that transmitter power may not be the limiting factor for deep space probes.

More difficult to solve are the guidance problems. Our best inertial systems are barely good enough to guide a probe to a point at which a homing system can take over for either a lunar satellite orbit or landing. For planetary probes, this is not good enough. Radio guidance giving midcourse corrections will help a great deal, but the required accuracies are still prohibitive. At 50 million miles, for instance, a tracking accuracy of one minute of arc means a lateral uncertainty of 16,000 miles.

Planetary probes with reason-

Table I: Satellite Instrumentation (1958)

Vanguard I (March)	Sputnik III (May)		Explorer IV (July)	Score (December)
Solar batteries	Solar batteries	Command receiver	Chemical batteries	Chemical batteries
Transmitters	Chemical batteries	Tape recorder	Transmitters	Transmitters
Temperature instruments	Transmitters	Timer	Scintillation counter	Command receiver
	lonosphere instruments	Programer	Geiger counter	Tape receiver (voice)
	Ceiger counter	Ion traps	Temperature instruments	
	Heavy-particle instruments	Electro static-field instruments		
	Solar-radiation instruments	Mg manometer		
	Temperature instruments	Ion manometer		
	Meteorite instruments	Mass spectrometer		
		Magnetometer		
		Satellite- orientation instruments		
		Heat regulator		

Table II: Atmospheric Data

Composition (per cent by volume)	Earth	Mars	Venus
O_2	21	0.3	
N_2	78	96	
A	1	4	
CO ₂	0.035	>50	
Pressure (mm Hg)			
Surface	760	64	
20 miles	9.5	approx. 10	
100 miles	2×10-6	>2×10 ⁻⁶	
Gravitational Force (cm-sec-2)	982	376	850
Surface Temperature (deg K)	295	260	370
Magnetic Field (gauss)	0,4-0.6	assumed somewha	

ably large payloads will probably have self-contained tracking systems, with a gyro-stabilized platform that keeps itself locked on to several fixed stars for accurate, space-fixed orientation. The platform would mount several planet seekers that could, for example, concurrently, track Mars, Venus, Jupiter, Saturn, and the earth. The tracking system could keep these reference directions within seconds of arc. If the angular positions of the seekers were to be transmitted to an earth-based computer station, the probe's position could be determined and corrections commanded

A whole new family of instruments will be needed as soon as landings on the moon or a planet are feasible. Measurements of force fields and radiations will still be needed, but the primary emphasis will be on surface analysis. Close-up TV pictures will be taken of the surface structure, surface hardness and porosity will be tested, and any dust layers or small-particle deposits will be studied.

Analysis of the deeper surface layers will involve seismic studies made possible by ejecting explosive charges from the probe. Microphones brought into contact with the surface will pick up tremors from impacting meteors or from quakes. Samples will be subjected to X-ray and spectrometric study and chemical analysis.—End

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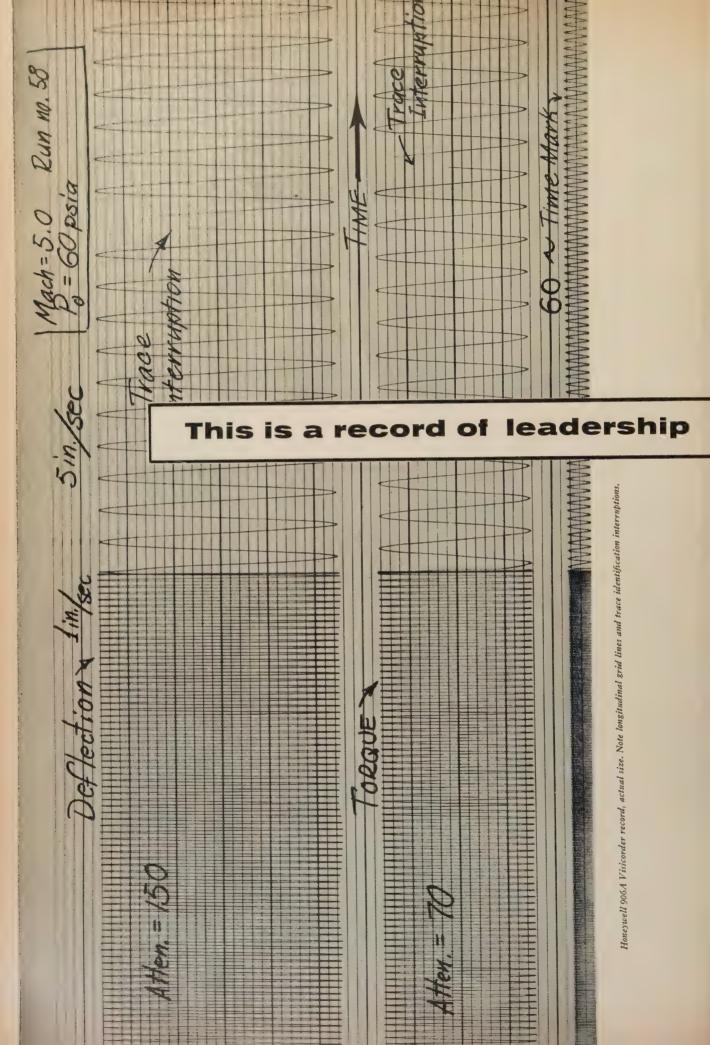
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These studies of aerodynamic damping coefficients on an airframe were made by engineers at ARO, Inc. They were conducted in the Gas Dynamics Facility at the U.S.A.F.'s Arnold Engineering Development Center, Tullahoma, Tennessee, wind tunnel center of the Air Research and Development Command. The studies were directly recorded on a Honeywell 906-A Visicorder.

The problem: To measure damping-in-pitch derivatives for a clipped-delta-wing-body configuration over a Mach number range of 2.0 to 5.0 so that these measurements could be compared with the Mach number trend predicted by theory.

The set-up: A model of the delta-wing body, mounted

on its cross-flexure pivot support, was forced to oscillate through a linkage by an electro-magnetic shaker. Resistance strain gauges were bonded to the input torque member and to one of the pivot supports. These gauges supplied torque and displacement signals through a carrier amplifier to two galvanometers in the Visicorder. An oscillator, driving a third galvanometer, established a time base for the oscillogram.

The values discovered through this forced-oscillation balance system experiment showed some discrepancies from values predicted by theory, because the theory pertained to simpler bodies than that used in the tests. The experiments provided a new set of data which will result in more accurate predictions for future design.

in aerodynamic research



Z. A. Woodard. Jr. ARO. Incorporated, instrument technician, operates the Visicorder in the measurement of aerodynamic damping coefficients.

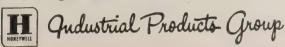
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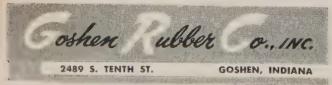
Reference Data: Write for Visicorder Bulletin Minneapolis-Honeywell Regulator Co., Industrial Products Group, Heiland Division 5200 E. Evans Ave., Denver 22, Colo.

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electronics scanner

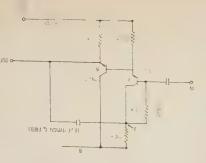
AT THE National IRE show back in March, Martin stirred up a lot of interest with 10 "typical" engineering problems it had run into. The company challenged all visitors to the show to work out the posers and offered awards for the best answers.

Like hundreds of others, we tried a few on for size and ever since have been curious to know if we were right. Now Martin has given SPACE/AERONAUTICS correct answers, and we're reprinting them on the next page. But first here are the problems:

- 1 The temperature in a miniaturized RF amplifier is maintained at a reasonable level by evaporative cooling into free air. In a plane flying at 25,000 ft above mean sea level, the developed power is 4.5 kw, with an overall efficiency of 68 per cent. How many gallons of water per hour are needed?
- **2** A nuclear isotope-powered thermoelectric generator is designed to deliver 1000 W at the end of 10 years. Assuming a constant thermal-electric energy conversion of 7.5 per cent, how much strontium 90 must be provided initially?
- **3** A satellite weighing 100 lb is to be placed into an equivalent circular orbit 500 miles above the earth's surface. Assuming an average earth radius of 3960 miles, what orbital velocity must be reached?
- 4 An airborne ground surveillance radar flying at 35,000 ft and 600 knots is to give a spot resolution of no worse than 500 ft diameter. Name and give suitable related numbers for the critical parameters that must be met.
- 5 A pilot ejected from a plane is free-falling. When he opens his parachute at 5000 ft altitude, he is subjected to a momentary maximum force of eight g. What would this force have been at 20,000 and at 40,000 ft, assuming the free-falling pilot is at terminal velocity at each altitude?
- 6 The CG of a space ship is stationary while the craft's longitudinal or thrust axis is rotating at 360 deg in 10 seconds about a perpendicular axis. A rocket engine is then started with a thrust of two g. What is the velocity and position of the ship one minute later?
- **7** A transistor ac-coupled emitter follower for operation at audio frequencies is to have an input impedance of at least one megohm. Assuming a B of 60 and a 10-K load impedance, show a circuit and suggest R and C values.
- 8 In a gyro-controlled inertial guidance system, the normal precession is balanced as nearly as possible by a torquer. In a 500-mile-range, 1000-mph missile of the Matador type, what is the allowable mean random drift error for a probable impact (azimuth) circle of two miles diameter?
- **9** The addition of copper impurity to germanium causes two acceptor states at 0.04 and 0.3 ev above the valence band. Assuming an adequately low temperature for testing, how would you make the 0.04-ev acceptor state photoelectrically inactive while retaining the photoelectric activity of the 0.3-ev acceptor state?
- 10 Barium titanate ceramic in the form of a hollow cylinder is used as a sonar underwater sound generator transducer. What dimensions must the cylinder have for resonance in the fundamental circumferential mode?

donor impurity to equal the copper impurity in concentration. Use at very low temperatures.

(10) The mean circumference of the BaTiO₃ ring must barione wave length of the driving frequency in mater.



values. (8) 0.057 deg/hr. (9) Add enough of a typical less, or negative, depending on phase and exact gain tion of the input impedance equals infinity. It will be to collector 300 K or through the 470 K, and this porvoltage. Hence no current flows through the base a voltage there that is equal to the to the 100-K and 470-K junction point 2 to develop than one megohm. The second transistor feeds back collector impedance (in the absence of the feedback circuit shown in the Diagram): 300 K, or much less impedance: 220 K \times B(=60)=13 Megohms; base-to-15 zero at the end of one minute. (7) Base-to-emitter reaches a point 6111.5 It from the origin. The velocity It and 35 g at 40,000 ft. (6) In one minute, the ship or less pulsewidth; 3000 pps. (5) About 14.5 g at 20,000 peak power; 10 db maximum receiver noise; 0.5 usec antenna disk (0.8-deg maximum beam-width); 50 kw 96.9 kg. (3) 16,673 mph. (4) Ka-band; 27-in. parabolic If all of the strontium is strontium 90, it would weigh (StTiO3) fuel, the initial gross weight would be 198.6 kg. ANSWERS: (1) 0.87 gph. (2) With strontium titanate

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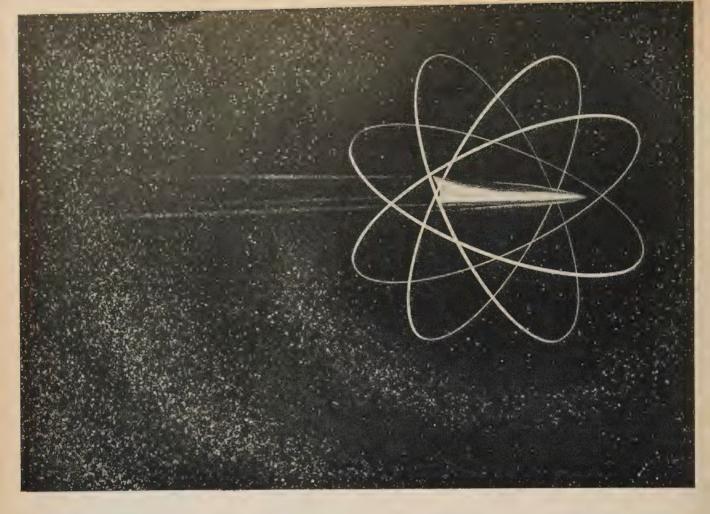
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a fence in the sky

The Westinghouse Air Arm Division has been selected to develop and build a fence in the sky ... an electronic defense system to shield the Air Force's 2000 mph B-70 Valkyrie.

This defense system will be a new dimension in electronic counter-measures, employing electro-magnetic and other techniques to delay, confuse and distort enemy intelligence. With its advanced technical developments, this system will greatly increase the manned aircraft's capacity for self defense.

The program, including advanced development and design work, will offer unique career development opportunities for engineers desirous of pioneering in the following fields:

AIRBORNE ELECTRONIC COUNTER-MEASURES

Signal Analysis

Systems Engineers
Broad Band Amplifiers
Digital Computer Design
Microwave Tube Design Antenna Design

CONTROLS & DISPLAYS

Circuit Design

Experimental Psychologists

GROUND SUPPORT EQUIPMENT

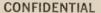
Automatic Check-out and Fault Isolation

FERRET RECONNAISSANCE **ELECTRONICS INSTRUCTORS** COMMUNICATIONS CIRCUITRY FIELD ENGINEERING TECHNICAL WRITING ELECTRONIC PACKAGING



FOR DETAILS... and a copy of the informative brochure "New Dimensions", send a resume of your education and experience to: Mr. A. M. Johnston, Dept. 945 Westinghouse Electric Corporation, P. O. Box 746, Baltimore 3, Maryland.







August 1959 (good until 10/15/59)

Employment Inquiry Form

(NOT an application for employment)

THIS INQUIRY FORM is a service that makes it easier for the interested reader to explore employment opportunities with organizations featuring recruitments advertising in this issue.

To use this Form, follow these simple steps:

- (1) Tear out this page.
- (2) Check off the organization(s) listed below whose employment offers are of interest to you. Use typewriter or pencil.
- (3) Turn to the back page of this Form and answer the questions on it.
- (4) Mail this form (in a stamped envelope) to:

Reader-Service Dept.

SPACE/AERONAUTICS

205 East 42nd St.

New York 17, N.Y.

We will do the rest and promptly forward a copy of your Inquiry Form to each of the organizations you have checked. Depending on their specific personnel requirements, they will get in touch with you at your home.

1	am interested in the employment opposition	rtun	ities	at:		
	Aeronutronic Div.; Ford Motor Co.		164	☐ Lockheed Aircraft Corp.		291
	AiResearch Mfg. Co. 166,	272,	278	☐ Los Angeles Div.; North American Aviation	168,	242
	Autonetics Div.; North American Aviation		163	North American Aviation		
	Bendix Aviation Corp.			☐ Autonetics Div.		163
	Bendix-Pacific Div.	167,	262	☐ Columbus Div.	104,	216
	Research Labs. Div.		168	☐ Los Angeles Div.	168,	242
	Chance Vought Aircraft, Inc.		164	☐ Rocketdyne Div.	172,	268
	Columbus Div.; North American Aviation	104,	216	☐ Pan American Airways, Inc.; Guided		
	Ford Motor Company; Aeronutronic Div.		164	Missile Range Div.		36
	Garrett Corp. 166,	272,	278	Raytheon Mfg. Co., The		173
	General Electric Co.			Republic Aviation Corp.		165
	Flight Propulsion Div.	166,		Rocketdyne Div.; North American		
	Heavy Military Elect. Dept.		293		172,	268
	Light Military Elect. Dept.		172	Rohr Aircraft Corp.		176
	Guided Missile Range Div.; Pan Am			□ Solar Aircraft Co.		170
	Airways, Inc.		36	Systems Development Corp.		171
	Hughes Aircraft Corp.		175	Texas Instruments		169
				☐ Westinghouse Electric Corp.		160

OTHER (Some organizations' recruitment advertising in this issue may have arrived too late for inclusion in the above list. If you are interested in the employment offers of any of these organizations, just note its name and the page number of its advertisement in this space. Please refer only to ads keyed to this form.):

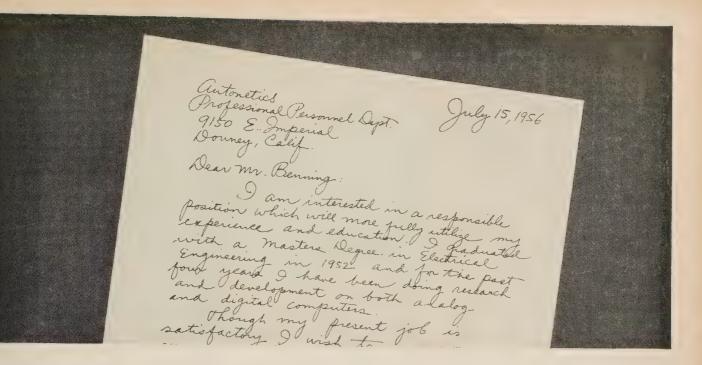
NOTE: If you have an immediate interest in any special employment opportunity advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We'd appreciate it if you'd mention SPACE/AERONAUTICS in your application.



August 1959

Employment Inquiry Form

Please type or print (with pencil)	(NOT an app	plication for e	mployment)
fields of interest (in order of importanto work—e.g., basic research, dynamics, strmatics, testing, materials, production, grou	uctures, rocket pr	opulsion, e	lectronic systems, pneu-
SPECIALIZED JOB EXPERIENCE (describe to e.g., flutter, fatigue, fuel systems, circu tool engineering, orbit mechanics, telemetry	iit miniaturization	, servo sys	tems, hydraulic pumps,
JOBS AND EDUCATION List your last 3 employers: EMPLOYER	CITY & STATE	YEARS EMPLOYED	JOB TITLE OR FUNCTION
List your college and university degrees: SCHOOL	YEA		DEGREE
Special TrainingPERSONAL DATA			
AGE U. S. CITIZEN TYES THOME Address: Home Address: Wake Sure You have above the your have above the sure you have above the sure you have above the sure you have above the your had your hard.	control the control to		



This letter moved an engineer ahead 5 years

Two years ago a man took 10 minutes to write this letter. Today he enjoys the responsibility and professional standing in the Autonetics Division of North American that might have taken 5 years to achieve elsewhere.

THE 20TH CENTURY'S MOST INTERESTING OPPORTUNITIES FOR THE CREATIVE ENGINEER

Now under way at Autonetics are over 100 projects—military and non-military—involving some of the most arresting and advanced work to challenge the engineering mind today.

WHERE IS YOUR FIELD OF INTEREST?

Inertial Navigation Systems—for aircraft and naval vessels with the organization that successfully flew all-inertial autonavigators more than eight years ago—and whose many-generation family of ever-improved inertial systems for manned and unmanned vehicles have made over 800 successful flights.

Radars—like the lightweight, monopulse type that guides aircraft to targets through fog and darkness and provides all radar functions for both high and low level missions—air-search, automatic tracking, ground-mapping and terrain-avoidance.

Flight Controls—fully automatic and reliable autopilots and landing systems.

Information Processing Equipment—including airborne magnetic tape recorders, transistorized analog or digital computers for both the military and industry, and pace-setting numercial control systems for three-axis position and path control of machine tools for industry.

At finger-tip nearness Autonetics has unique experience, advanced tools and techniques plus precision machine shops turning out work to millionths of an inch tolerances in both developmental and volume quantities.

Opportunities have never been better—at every level of creative engineering from Preliminary research and design to Performance test—because Autonetics is one of the few companies in the world designing and quantity-producing systems within the complete spectrum of electronics, electro-mechanics, control engineering and data processing.

Write today and tell us what kind of creative engineering interests you (please include highlights of your education and experience).

Write D. H. Benning, Manager, Employment Services. 9150 E. Imperial Highway, Downey, California





NEW VOUGHT PROJECTS OFFER CAREER APPEAL TO CREATIVE MEN

exploratory work in wide variety on new metals, methods and weapons

Chance Vought is advancing on many fronts. In Astronautics there is development of the 4-stage "Scout" research rocket for NASA. In Antisubmarine Warfare, detection and classification studies for the Navy. In Advanced Weapons, hypersonic systems are in development. Electronics for weapons - and for advanced control systems - are being developed by Vought. The company's Range System Division is managing key missile ranges. These activities have prompted exploratory work in the following areas:

Structures (Supersonic and Hypersonic)

Heat transfer, thermal stress and deflection analysis, and stress analysis using high-speed computers.

Manufacturing R & D

Welding and brazing of super alloys and exotics; advanced forming and cutting studies; prediction of metal fabricability.

Industrial Engineering

Project estimating, work sampling, line load and balance, and packaging and installation of new procedures.

Antisubmarine Warfare

Studies of detection and classification techniques involving Acoustics, Geomagnetism, Geophysics, Electromagnetics, Electrochemistry, Math.

Engineering Planning

Man-hour and budget forecasting, and project planning and scheduling.

Product Design

Automatic escape devices, atmospherically sound cockpits and advanced instrument displays for space pilot, crew.

Flight Test Instrumentation

R & D in new techniques for electronic gathering and reducing of flight test data.

Aerodynamics

Wind tunnel and model work employing Vought's 3,800-mph highspeed wind tunnel and new "high-temperature" laboratory.

Qualified applicants are invited to write:

Ass't. Chief Engineer, Administrative Dept. 0-7





Check Employment Inquiry Form on Page 161

ENGINEERS & SCIENTISTS

RESEARCH OPPORTUNITIES

Aeronutronic, a new division of Ford Motor Company, has immediate need for qualified people to staff senior positions at its new \$22 million Research Center in Newport Beach, Southern California.

The Space Technology Operation offers the highly desirable combination of new facilities and advanced equipment, located in California's finest environment for living and raising a family. Investigate these exceptionally rewarding positions now:

VEHICLE TECHNOLOGY

Aerodynamic design and testing Rocket engine development Rocket nozzle and reentry materials High temperature chemical kinetics Combustion and detonation theory Combustion thermodynamics High temperature structural plastics & ceramics Advanced structures Rocket vehicle systems

MISSILE DEFENSE

Supersonic aerodynamics Aerothermodynamics High temperature heat transfer Space physics Re-entry programs

ASTRO SCIENCES

Space electronics Guidance & control Communications Instrumentation Experimental physics Plasma and magnetohydrodynamics studies

Visit Aeronutronic's exhibit booth 3822-24 at the WESCON show.

Qualified applicants are invited to send resumes and inquiries to Mr. R. W. Speich, Aeronutronic, Dept. 11, Box 451, Newport Beach, California.

AERONUTRONIC

a division of Ford Motor Company Newport Beach Santa Ana . Maywood, California



JOIN REPUBLIC IN AN INTEGRATED ATTACK ON PROBLEM AREAS OF SPACE EXPLORATION

It's the fervent conviction of engineers and scientists at Republic Aviation that the courageous "Space Time-Table" above is entirely feasible – given a tradition-free, integrated approach to the

problems. Such an approach is evident at Republic Aviation. Here, groups of specialists from many disciplines are working in close collaboration to solve problems across the entire spectrum of space technologies, which limit today's interplanetary and upper atmosphere flight capabilities.

Expanded by \$35,000,000 last year, Republic's integrated Research and Development program has already produced signal advances in space guidance concepts; in new propulsion systems (plasma, nuclear); in radiation physics; in new materials and processing techniques; in unique hypersonic configurations; and in prototype development of hardware (as an example: hydraulic systems that operate reliably up to 1000°F).

Professional men—who can meet new challenges with enthusiasm and dedication—are urged to look into openings with our R&D groups, working in an atmosphere of exhilarating intellectual adventure.

Electronics

Inertial Guidance & Navigation
Digital Computer Development
Systems Engineering
Information Theory
Telemetry:SSB Technique
Doppler Radar • Countermeasures
Radome & Antenna Design
Microwave Circuitry & Components
Receiver & Transmitter Design
Airborne Navigational Systems
Jamming & Anti-Jamming
Miniaturization — Transistorization
Ranging Systems
Propagation Studies
Ground Support Equipment

Thermo, Aerodynamics

Theoretical Gasdynamics
Hyper-Velocity Studies
Astronautics Precision Trajectories
Airplane/Missile Performance
Air Load and Aeroelasticity
Stability and Controls
Flutter & Vibration
Vehicle Dynamics & System Designs,
High Altitude Atmosphere Physics
Re-entry Heat Transfer
Hydromagnetics
Ground Support Equipment

Plasma Propulsion

Plasma Physics
Gaseous Electronics
Hypersonics and Shock Phenomena
Hydromagnetics
Physical Chemistry
Combustion and Detonation
Instrumentation
High Power Pulse Electronics

Nuclear Propulsion and Radiation Phenomena

Nuclear Weapons Effects Radiation Environment in Space Nuclear Power & Propulsion Applications Nuclear Radiation Laboratories



Send resume in complete confidence to: Mr. George R. Hickman, Engineering Employment Manager, Dept. 6H

REPUBLIC AVIATION

Farmingdale, Long Island, New York

MILITAI

TURBOJET

Action and Opportunity in Every

Aspect* of Flight Propulsion

at General Electric

ACCELERATING PROJECTS CALL FOR OVER 400 EXPERIENCED ENGINEERS AND SCIENTISTS IN RESEARCH, DEVELOPMENT, FINAL DESIGN, TEST AND PRODUCTION.

At Flight Propulsion Division, the creative aspects of science and engineering are recognized, stimulated and appreciated. Here your professional progress is speeded because your growing experience can be matched with increased responsibility. FPD affords its technical staff a high ratio of carefully selected support personnel, modern equipment and facilities, plus encouragement to present and publish papers (last year 168 papers were presented or published by the FPD staff).

A Wealth of Living and Professional Advantages. FPD's Cincinnati location offers the engineer and his family a host of benefits and opportunities. This friendly city has fine schools, plentiful housing, over 30 active professional societies, and many cultural activities.

For detailed information about a career at Flight Propulsion Division, write for brochures #50 and #51. For immediate placement consideration, enclose your resume in complete confidence.

Write: Dr. Mark Elwood, Bldg. 100, Dept. 60-MH

FLIGHT PROPULSION DIVISION

GENERAL

Cincinnati 15, Ohio

COMMERCIA TURBOIL

PROPULSIO PROJEC"

> SPECIA PROJECT!

GROW WITH AIRESEARCH IN ELECTRONICS

*(The chart at right is a selected "matrix" of current activities and opportunities at FPD. It does not indicate all

of our projects or openings.)

AiResearch expansion in electronics and electromechanical activity is creating outstanding positions at all levels for qualified engineers.

DATA SYSTEMS RESEARCH

Experience with physical measuring devices using electromagnetic, atomic, thermionic and mechanical approaches.

Openings also exist in the following areas: Flight Systems Research... Controls Analysis ...Flight Data Components...Electromagnetic Development...Instrument Design...Airborne Instrumentation Analysis and Design.

Send resume to: Mr. G. D. Bradley



AiResearch Manufacturing Division

9851 So. Sepulveda Blvd., Los Angeles 45, Calif.

Investigating Employment **Opportunities?**

Want more information about employment opportunities offered by companies advertising in this issue? Then be sure to give complete data about your job interests, experience and education when filling in the "Employment Inquiry" form.

Although not an application for employment, it provides employment managers with information to evaluate your capabilities-and in turn gives your request immediate consideration.

Check the "Employment Inquiry" form for details.

Check Employment Inquiry Form on Page 161

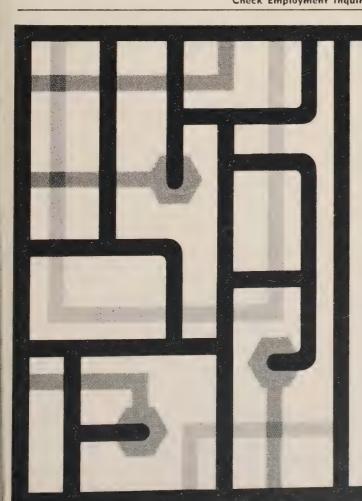
DESIGNATION APPLICATION		STATUS	RATING	FEATURES	
J-79	F-104, B-58, F4H-1, A3J, F11F-1F	Production	More than 15,000 lb. thrust	Has 90% of all U.S. Mach 2 flight time	
TF-35	Near sonic military transports and logistics aircraft	Test and evaluation	More than 15,000 lb. thrust	Successfully completed 1,000 hr. test	
J-93	F-108, B-70	Design and development	Mach 3+	Will cruise at altitudes in excess of 70,000 ft.	
X-211	Nuclear powered aircraft	Classified	Classified	Classified	
CJ-805-3	Convair 880	Test and evaluation	15,000 lb. thrust	Many hot parts have run 2,500 hrs., are reinstalled and are running additional tests	
CJ-805-23	Convair 600	Test and evaluation	CJ-805 with aft fan	7 engines running, with one completing 600 hrs. and two, 150 hrs.	
Rocket Motor Casings	Solid propellant missiles and rockets	Research, design, development and production	N/A	Hydroforming techniques have led to increased strength/reduced weight	
Rocket Motor Nozzies	Solid propellant missiles and rockets	Research, design, development and production	N/A	Revolutionary spray-on tungsten technique has been developed	
Liquid Rocket Engine	Second stage for Vega vehicle	Design and development	N/A	Adaptation of Vanguard engine for space research	
on and Plasma Propulsion	Manned space vehicles	Applied research	Undetermined	New theories have been developed applicable to manned space flight	
it/TOL Project	Fixed wing aircraft	Design and development	N/A	New technique gives fixed wing aircraft capability for vertical takeoff and landing	
Boost urbojet	Will be used to launch satellites and space vehicles	Feasibility studies and research	N/A	Recoverable first-stage launching powerplant	

IMMEDIATE OPENINGS AT ALL LEVELS IN THESE AREAS:

Turbomachinery Aerodynamics Nozzle Design Reliability Performance & Cycle Analysis Installations/Applications Component Design **Electrical Component Design** Mechanical Component Design Servomechanisms Reliability Test Facilities Engineering Instrumentation Development Manufacturing Engineering Controls Test Equipment Design Liaison Engineering Statistics Metallurgy **Analytical Chemistry Mathematics** Computer Programming Thermodynamics Stress & Vibration Heat Transfer & Flow Controls Engineering X-Ray & Electron Microscopy **Materials Testing** Plasma Physics Magnetohydrodynamics Aerodynamics Airframe Design Feasibility Studies Address: Dr. Mark Elwood, Bldg. 100, Dept. Whirt Flight Propulsion Division, General Electric Company,

Cincinnati 15, Ohio

Check Employment Inquiry Form on Page 161



in Southern California needs
missile / aircraf

missile/aircraft valve design engineers

Bendix-Pacific Offers You Career
Positions in Southern California — WE NEED:

- Electro-hydraulic high performance servo valve development engineers with 4-6 years experience and a B.S.M.E. degree.
- General hydraulic valve designers with 2 to 4 years experience and a B.S.M.E. degree.
- 3. Pneumatic valve and servo designers with 2 to 4 years experience and a B.S.M.E. degree.

PLEASE SEND RESUME TO W. C. WALKER ENGINEERING EMPLOYMENT MANAGER



11630 Sherman Way, North Hollywood, California

Other High-Level Engineering Positions Available.

ADVANCED DIGITAL TECHNIQUES, COMPUTERS AND CONTROL SYSTEMS

- AIRBORNE DIGITAL EQUIPMENT
- NUMERICAL MACHINE CONTROL
- HYBRID ANALOG-DIGITAL SYSTEMS
- ADVANCED STORAGE TECHNIQUES
- NEW LOGICAL STRUCTURES

Engineers and scientists needed with experience in all phases of digital computer technique and equipment development. Systems organization, logical design, transistor circuitry, magnetic core and drum memories, input-output equipment, packaging. Applications, both commercial and military, include airborne digital equipment, numerical machine control, and hybrid analog-digital systems. Advanced development and research on a wide variety of new components and logical structures.

We think you will find this work unusually stimulating and satisfying; we would welcome the opportunity to discuss it with you in person. Comfortable and pleasant surroundings in suburban Detroit. If interested, please write or wire Fred A. Barry, Research Laboratories Division, Bendix Aviation Corporation, Southfield, Michigan.

Research Laboratories Division

P.O. BOX 5115 DETROIT 35, MICHIGAN





TRAINING EQUIPMENT DESIGN

The Los Angeles Division of North American Aviation — Weapon System Contractor for the nation's two most advanced manned weapon systems, the B-70 and F-108—has top-level positions available for

Training Simulator Designers

These highly-qualified engineers will coordinate and monitor the over-all design of training simulator equipment for the most advanced weapon systems projects.

Background preferred: Graduate Electrical Engineer with minimum of four years' experience in design of analog and digital computers with application to simulation requirements.

For more information please write to: Mr. P.H. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

THE LOS ANGELES DIVISION OF

AMERICAN AVIATION. INC



Submarines can hide within range of helicopter-borne sonar by "riding the thermocline"—a water temperature change that casts shadows in sonar search patterns. Precise temperature-vs.-depth records allow the operator to spot thermoclines and change his search pattern to look into the shadows. Existing gear "worked", but it took too long and could not define the shadow zones very accurately. TI engineers created an automatic recorder, the bathythermograph, more accurate than a laboratory thermometer, that gives results instantly where they were needed — in the helicopter. Small as a portable typewriter, it easily fits with the sonar into the space available. RESULT: Same sonar—fewer missed submarines.



esign, manufacturing and quality engineers — 3 - 10 years experience

nigh-gain careers for problem-solvers

OUR SPECIAL TOUCH with unsolved problems buys you a solid future in my of Texas Instruments major military programs — Antisubmarine Warfare, eavy Surface Radar, Missile Systems, or Electronic Surveillance. For exame, you can try your hand at solving the Navy's clearly stated ASW requirement: Build something that will detect and classify a fast-moving submerged braine at depths of 1500 feet, more than 50 miles from your aircraft. Our experience in one of the following technologies may find immediate uplication in one of our four major programs:

radar • sonar • infrared • magnetic anomaly detection • passive detectors • servos • navigational systems • special-purpose computers • timers • programmers • microwave • telemetering • data link • optics • video mappers • visual displays • intercom

e require a steady influx of exceptionally-qualified men in these technologies. I learn more about us and how we can fit into your career plan, write for a py of "We can tell you this much about Apparatus division" to:

J. R. Pinkston

Professional Placement

APPARATUS DIVISION





INSTRUMENTS

6000 LEMMON AVENUE . DALLAS 9, TEXAS

Check Employment Inquiry Form on Page 161

current career openings

EE's & PHYSICISTS:

radar (ground and airborne), antenna & microwave components, missile guidance, servo-mechanisms, telemetry, digital circuits, infrared design, systems studies, & flight test.

ME's:

antenna, mechanisms, miniaturization, thermodynamics, refrigeration, insulation, packaging, & structures design.

INDUSTRIAL ENGINEERS:

cost estimating, quality control, & quality assurance studies.

MANUFACTURING ENGINEERS:

tooling design & manufacturing planning & supervision. (Degrees in EE or ME.)

write for your copy



Key Positions open for

HIGH LEVEL ENGINEERS

MANAGER, DEVELOPMENT
CHIEF, AVIONICS
CHIEF, ASTRO-AERO SCIENCES
CHIEF, PRELIMINARY DESIGN
CHIEF, STRUCTURES

These five brilliant career openings are the result of the rapid expansion of Solar's Space Age R&D program. Current projects are exceptionally exciting and challenging, including an ARPA project for a completely new anti-missile defense system. Advanced degree preferred plus ten years experience in aircraft, missile and space flight fields. Learn complete details immediately.

SOLAR SPECIFICS

Solar is a medium-size company (2500 people in San Diego) with a successful history since 1927. Solar is making many significant contributions to space-age technology and the special professional status of engineers is fully appreciated and recognized. A new 60,000 sq. ft. engineering building, necessitated by expanding R&D work, will be completed this year on the edge of San Diego Bay. Solar also offers you the chance to live better in sunny San Diego. This famous resort area has the finest year-around climate in America and excellent cultural, educational and recreational facilities. You and your family will enjoy life more at Solar in San Diego.

SEND RESUME

Please send resume of your qualifications at the earliest opportunity to Louis Klein, Dept. E-419, Solar Aircraft Company, 2200 Pacific Highway, San Diego 12, Calif.



ATTENTION EMPLOYMENT MANAGERS

This new "Employment Opportunities" section allows you greater choice in positioning advertisements—in keeping with your recruitment objectives.

If the purpose of your campaign is to alert readers to immediate job openings you'll find the new section ideal for this need.

If, on the other hand, your aim is to acquaint readers with your organization—the scope of its operation, new projects getting underway, extra benefits, etc.,—you may find any other part of the magazine more suitable for this purpose.

But no matter where you position your employment advertising, your company will be listed on the "Employment Inquiry" form which appears in this section.

Although not an application for employment, it provides you with detailed information about technical personnel interested in your company. After evaluating their specialized job interests, experience and formal education—which must be included in the form before it is sent to you—you can personally contact those best qualified for the job.

When scheduling your recruitment advertisements in Space/Aeronautics, be sure the insertion order specifies where you want the advertisement to appear—"run-of-book" or in the "Employment Opportunities" section.

"SYSTEM DEVELOPMENT CORPORATION

is currently seeking scientists and engineers in various skill areas. As part of this effort, I have been given the opportunity to tell you something about our organization.

"Let me begin by giving you some general facts about the Corporation: SDC is a non-profit organization chartered to work in fields pertaining to public welfare, the advancement of science, and national defense. The Corporation's name implies its function—the development of systems. Specifically, we are concerned with large, complex information processing systems with a high degree of automation. Development of these systems is accomplished through the application of knowledge in the areas of applied mathematics, engineering, and psychology, to problems of over-all system design, lata processing techniques and optimum man-machine relationships,

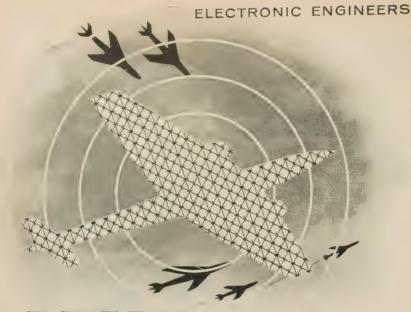
'Our work is system-oriented, rather than concerned with the lesign or manufacture of hardware components. As a result of this ype of specialization, we have assumed major responsibilities in the levelopment of systems such as the SAGE (Semi-Automatic Fround Environment) Air Defense System and the world-wide itrategic Air Command Control System, and in the integration of the functional responsibilities of these systems with other military lectronic support systems.

Because the scope of our activities is rapidly increasing, we are expanding our staff. In this message I am specifically addressing oung engineers with advanced training and proved analytical bility in the areas of weapons system analysis, noise and information theory, ECM, electromagnetic intelligence and allied elds. If you are qualified, and our corporate activities sound teresting to you, we would like to hear from you. Address inquiries garding our Santa Monica, California facility to Mr. R. W. Frost, 124 Colorado Avenue, Santa Monica, California. Inquiries regarding in Lodi, New Jersey facility should be addressed to Mr. R. L. Obrey, 3x 2651, Grand Central Station, New York 17, N.Y. These gentlemen II see that your letter receives prompt attention and confidential matment."

David Green; Assistant Director for Plans, Operations and Management Research Directorate

SYSTEM DEVELOPMENT CORPORATION

SANTA MONICA, CALIFORNIA - LODI, NEW JERSEY



AEW with the automated voice of command....

ANOTHER OF THE MANY ADVANCED PROJECTS
ATTRACTING ENGINEERS TO GENERAL ELECTRIC'S
LIGHT MILITARY ELECTRONICS DEPARTMENT

Light Military is developing a new concept in Airborne Early Warning and Control which will provide protection for a mobile unit by detecting enemy aircraft at unprecedented ranges, tracking, adapting itself to changing combat situations, and transmitting tactical data *automatically* to combat information centers. The system will match a 3-Dimensional radar with novel correlation techniques and an automated data handling system which — for the first time — will practically eliminate Man from the control loop.

AT LIGHT MILITARY CAREER OPPORTUNITY SPANS THE EM SPECTRUM - FROM AUDIO TO INFRARED

Automated AEW is but one of the many advanced programs you will find at Light Military. Projects such as Polaris Fire Control and Guidance Computers, ICBM Atlas Guidance, Airborne ECM, and Airborne Navigation Systems offer creative engineers and scientists unmatched opportunities to apply imaginative and novel approaches toward resolving formidable engineering problems. There are immediate openings in these areas:

CIRCUIT DESIGN
MICROWAVE DEVICES
IF AMPLIFIERS
RADAR RECEIVERS &
TRANSMITTERS

DISPLAY DEVICES & VIDEO INDICATORS
SERVOMECHANISMS

SERVOMECHANISMS
TRANSISTOR CIRCUITRY
TRAVELLING WAVE TUBES

AERODYNAMICS
DATA PROCESSING &
DIGITAL TECHNIQUES
INFRARED
VIBRATION & SHOCK

Forward an outline of your experience or your resume in strict confidence to: Mr. W. Gilmore, Dept. 60-MH



LIGHT MILITARY ELECTRONICS DEPARTMENT

GENERAL (ELECTRIC

FRENCH ROAD, UTICA, NEW YORK

A SPECIAL MEMO FROM ROCKETDYNE TO A PHYSICIST

Rocketdyne, the Nation's leader in Research & Development of high and low thrust propulsion systems, has a position demanding

PROJECT RESPONSIBILITY

for a Senior Research Scientist or Specialist to perform

THEORETICAL—EXPERIMENTAL
RESEARCH in
ELECTRICAL PROPULSION

including

IONIZATION OF SPECIES
ELECTRICAL DISCHARGE
PHENOMENA
ION ACCELERATION

Desired Qualifications: PhD degree and five years of applicable experience.

Please write:

Dr. R. S. Levine, Chief, Physical Sciences Section, Dept. 596-FH, Rocketdyne Propulsion Field Laboratory, Chatsworth, Calif.

ROCKETDYNE IR

A DIVISION OF NORTH AMERICAN AVIATION, INC.
First with Power for Outer Space

NEW PROGRAM

Raytheon enters new weapons systems program and offers advancement opportunities for both Junior and Senior electronics engineers with experience in the following fields:

- Microwave engineers—component and antenna design
- Communications systems
- Guidance systems
- Computer systems
- Radar systems
- Inertial reference systems
- Feed-back control
- Auto-pilot
- Ground support
- Electronic packaging engineers
- Radar systems engineers (project management)
- Electromechanical engineer for missile control and auto-pilot design (project management)
- Mechanical engineer experienced in ground handling of large missile systems (project management)

You and your family will enjoy the many advantages of living in the metropolitan Boston area. Relocation assistance and modern benefits.

Please forward resume to:

Mr. W. F. O'Melia Employment Manager Raytheon Company Bedford, Mass.

or call collect:

Crestview 4-7100 Extension 473



RADAR ENGINEER RADIO NOISE ENGINEER

You are invited to investigate unusual career opportunities with excellent futures in the science and engineering Laboratories of IBM. You will find this a unique opportunity to contribute original thinking on several important projects.

Our Laboratories are engaged in the research and development of advanced electronic digital computers and control systems for the exotic-fueled B-70 strategic bomber, being designed to operate at altitudes of 70,000 feet and at speeds of more than 2,000 miles per hour. We have, in addition, projects in progress on future strategic air weapons, including global satellites, offensive bombardment space vehicles, and missiles.

Radar Engineer: To be responsible for technical coordination and liaison with major radar contractors on advanced microwave system. Should have theoretical and design knowledge of microwave engineering field. Familiarity with monopulse radar and doppler techniques is desired. A B.S. or advanced degree in Electrical Engineering with at least two years' experience on radar systems development projects is desired.

Radio Noise Engineer: To advise our departments about circuit design and packaging of digital computers, radar displays and servo equipment; to write specifications which describe techniques, procedures, and processes required for design; to define system grounding methods to minimize interaction between circuits. Should have experience in the design of complex military systems and in the definition of test programs to meet applicable military specifications. A B.S. or M.S. in Physics or Engineering Science with at least two years' experience in radio noise is desired.

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Mr. R. L. Lang, Dept. 522H IBM Corporation Owego, New York



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Opportunities?

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Although not an application for employment, it provides employment managers with information to evaluate your capabilities — and in turn give your request immediate consideration.

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Mr. Robert A. Martin, Supervisor, Scientific Employment Hughes Research and Development Laboratories

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Culver City 69, California



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Address			
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College		Degree	Year
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CHULA VISTA AND

Check employment Inquiry Form on Page 161

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If the purpose of your campaign is to alert readers to immediate job openings you'll find the new section ideal for this need.

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But no matter where you position your employment advertising, your company will be listed on the "Employment Inquiry" form which appears in this section.

Although not an application for employment, it provides you with detailed information about technical personnel interested in your company. After evaluating their specialized job interests, experience and formal education —which must be included in the form before it is sent to you —you can personally contact those best qualified for the job.

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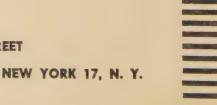
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Actuators

product index to advertising

THIS IS A SPECIAL REFERENCE to the product information given in the advertisements in this issue. It is intended solely to help the reader make the best use of these ads. Therefore the index does not necessarily cover all the products made by each advertiser. Also, cross-listings are not intended to exhaustively describe each product but merely to make sure that each product can be found with reasonable ease by the reader looking for it. Similar indexes to services and employment opportunities featured in ads follow this index. Advertisements for which complete proofs were not available to the Editorial Department by the closing date are not necessarily covered by these indexes. (Proofs can be forwarded internally by the Production Department only for advertisements meeting the closing dates.)

For more detailed information on any product or service advertised in this issue or featured in its Product and Data Reviews, use the handy Reader-Service Card.

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Missile and rocket components, impact extruded from Alcoa Aluminum. The largest impact shown above has 8-in. diameter, 36-in. length; Alcoa can make them as large as 12-in. diameter, 60-in length. The impacts shown use aluminum alloys 1100, 6061-T6, 2024-T4 and 7075-T6.

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EACH OF THE IMPACTS shown above is in production. Each represents at least one complexity that formerly

would have posed a real production headache: each achieves the optimum properties of its particular alloy.

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consider virtually any closed-end or tubular design as an Alcoa® Impact. For more specific information, and for on-the-spot assistance, the best procedure is to contact your nearby Alcoa sales office. Or, if you prefer, write to: Aluminum Company of America, 2027-H Alcoa Building, Pittsburgh 19, Pa.

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- 2 Product Development by experienced specialists in your field of interest.
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- 4 Service Inspectors to help solve production problems in your plant.
- 5 Quality Control to meet demanding standards and to match your special needs.
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- 8 Sales Administrators, constantly on call to service your orders.

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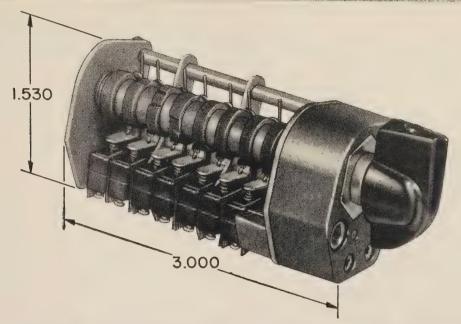
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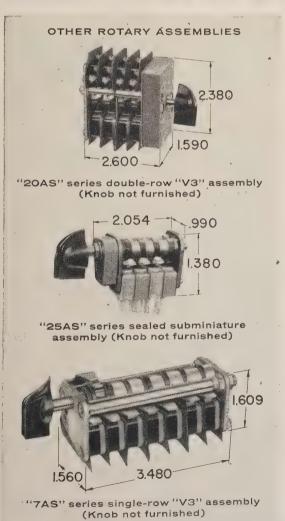


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New rotary selector switch assemblies feature "cock-and-fire" actuation



The new "28AS" Series of rotary selector switch assemblies have a "cock-and-fire" actuating mechanism that moves positively from one position to another, imparts a good feel of the detent action and provides immediate indication of each position. Aircraft engineers have found these switches ideal for mounting in close-coupled designs. Features include:

Reliable Operation

Individual actuating levers pivot on a common rod, insuring maintained adjustment. The levers are operated by precision cams which are rigidly mounted on the actuator shaft. A seal ring on the shaft keeps out moisture. Panel seals are optional.

"Non-Tease" Circuitry

The actuating mechanism moves positively from one position to another. There is no possibility of circuit "tease" or actuator "hang-up" between the 90° detents.

Variety of Sequences

Up to seven basic switches and two or three actuator positions may be provided. Innumerable sequences can be factory-adjusted to fit specific circuit requirements.

Send for Data Sheet 162

For information of the "28AS" Series or other versatile MICRO SWITCH rotary switches, consult experienced engineers at your nearby branch—or write to:

MICRO SWITCH ... FREEPORT, ILLINOIS

A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario



Write in No. 270 on Reader Service Card at start of Product Preview Section

COATING

FABRIC SUBSTRATES

	COTTON	NYLON	"DACRON"*	GLASS	"TEFLON"*	
NEOPRENE				•		
BUNA-N	•	•		•		
"FO" †	•	•				
BUTYL	•	•				
"HYPALON"*		•	•	•		
ACRYLIC			•	•		
SILICONE			•	•	•	
"VITON"*				•	• .	

^{*}Registered Du Pont trademark +A Du Pont trade name

At Du Pont special coatings are combined with selected fabrics to produce "Fairprene" having the advantages of both. Tabulated above are many of the combinations possible. Fabric can have balanced coating on each side; can have one side bare; or more or less heavily.

coated than the other; or a different coating on each side. "Fairprene" can have more than one layer of fabric enclosed or can have compound between layers of fabric. Thus "Fairprene" is remarkably versatile material tailor-made for an extraordinary range of applications.

These elastomer-fabric combinations of Fairprene® form design materials of marvelous versatility

Exciting new design materials with an outstanding range of capabilities are created by the exclusive calendering-coating process that forms "Fairprene". Using this process, Du Pont creates many materials from elastomer and fabric with many variations in their chemical and physical properties. Du Pont engineers are eager to help you evaluate "Fairprene" for designing new products or improving present ones. Mail the coupon or write E. I. du Pont de Nemours & Co. (Inc.), Fabrics Division SA-98, Wilmington 98, Delaware, for complete information.

INDUSTRIAL COATED FABRICS SHEET STOCKS · CEMENTS



BETTER THINGS FOR BETTER LIVING...THROUGH CHEMISTRY

Can your product be added to this growing list of applications for Du Pont"Fairprene"* coated fabrics?

Aileron Seals Airforms Air Seals Air Shelters Aprons Balloons Bearing Seals Boots and Bellows Cable Wrap Carburetor Diaphragms Compressor Diaphragms Condenser Seals Control Device Diaphragms Dielectric Sealing Vent Distributor Diaphragms Draw Sheets Engine Baffles

Fire Curtains
Flexible Ducting
Flow Meter Diaphragms
Fuel Bags
Fuel Cell Seals
Fuel Economizer Diaphragms
Fuel Injection Unit Diaphragms
Fuel Pump Diaphragms
Foundation Blankets
Gaskets
Gouge Strips
Instrument Diaphragms
Landing Mats

Laundry Roll Covers Lightweight Belting Meter Bellows Meter Diaphragms Missile Blast-Deflection Curtains Modulator Diaphragms Packings Propeller De-icers Protective Clothing Pump Cups Pump Diaphragms Radar Antenna

Microphone Covers

Radomes
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Tarpaulins . . . Tents
Top Sheets
Vacuum Device Diaphragms

Vacuum Device Diaphragms Vacuum Molding Bags Water Bags

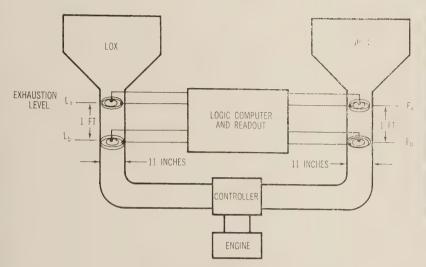
* * "Fairprene" is Du Pont's registered trademark for its coated fabrics, sheet stocks and cements

E. I. du Pont de Nemours & Co. (I Fabrics Division SA-98, Wilmington Please send me further inform in using a coated fabric for	on 98, Delaware ation about coated fabrics. I am interested
Name	Title
Firm	
Address	

Write in No. 271 on Reader Service Card at start of Product Preview Section



equipment briefs



RESIDUAL PROPELLANT METER

Als capacitance measuring system was developed by Magnetic Instruments Co., Inc., 546 Commerce St., Thornwood, N. Y., to test the operation of a fuel controller for a liquid rocket engine. The problem was to find out exactly how much liquid oxygen and JP-4 was left at cutoff. At the instant of measurement, the two liquids are traveling through 11-in. pipes at up to 25 fps. The residual propellant has to be measured to the nearest pound.

Magnetic Instrument's solution was to locate two very thin coaxial capacitor level sensors in each pipe. As the liquid interface passes the sensors, the capacitance changes sharply. This change is translated into a dc voltage level change. The residual liquid can be immediately identified by recording which sensors produce the first pulse.

The pulses developed by the four sensors are used to measure the time interval between level interfaces as they pass each sensor. A logic system is used as well as two electronics counters operating from a 10-ke clock.

A flow rate measurement is needed to convert the time intervals into volume. It is provided by the same capacitor level sensors and a second logic set. The sensors are spaced exactly 12 in. apart in the pipes so that the volume is precisely defined.

The flow rate is measured by measuring the time required to pass from the level of one capacitor pair to that of the other. Once the flow rate is known, the time interval representing residual liquid can be converted into volume by multiplication. Circle No. 56 on Reader Service Card for more information.



CONVERTER FOR NUMERICAL CONTROL

THE first Numericord director in this country has been installed at Boeing-Wichita's tape center, set up under an agreement between the company and the Air Force. It is used to produce magnetic tapes for numerically controlled machine tools.

Various types of numerically controlled machines have different control systems. Some used punched tape or cards, while others use magnetic tape. Boeing's Numericord director, built by Concord Control, Inc., 1282 Soldiers Field Rd., Boston, Mass., can convert machine commands on punched paper tape to electric signals on magnetic tape. Thus Boeing is set up to process tape for any kind of numerically controlled machine.

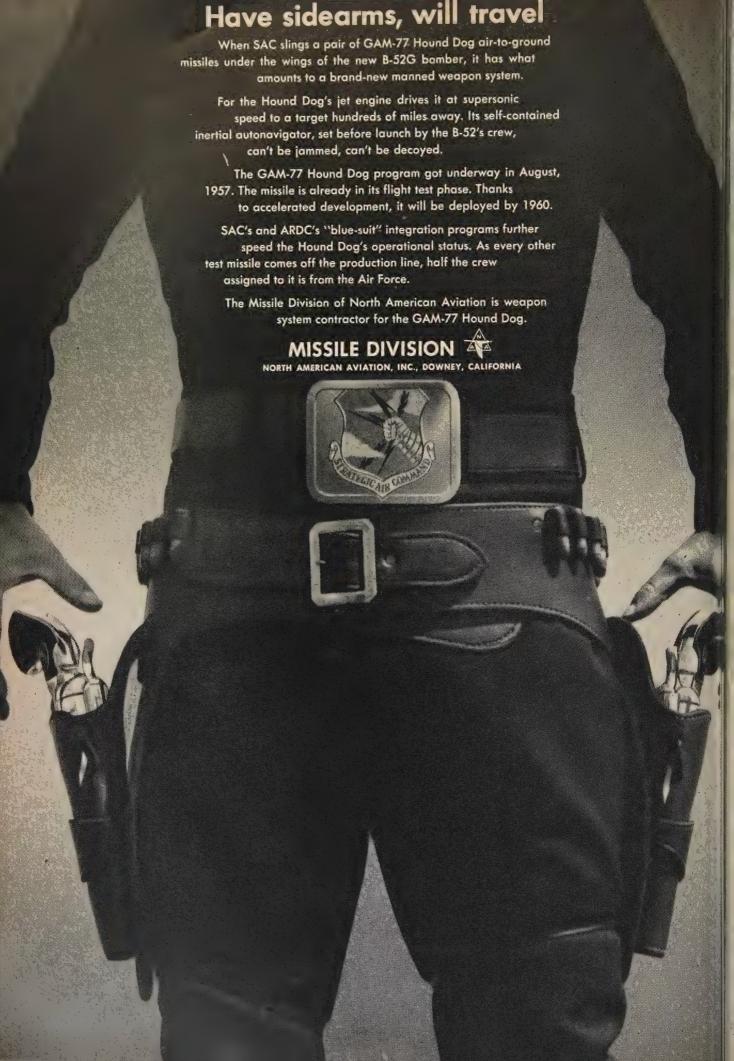
The tape is made of a one-inchwide clear Mylar plastic with an iron oxide coating on one side. It has a 14-channel capacity for magnetic charges. It is one mil thick and comes in reels of 7200 ft. For milling a wing skin panel of the B-52G (below), Boeing uses 17 tapes. Circle No. 60 on Reader Service Card for more information.



POLYURETHANE REPLACES RUBBER

SOLID polyurethane material produced by Disogrin Industries, Inc., 510 S. Fulton Ave., Mt. Vernon, N. Y., is said to be 4-5 times more wear-resistant than rubber. It has been used to replace rubber on the tail wheel of the operational Douglas F4D Skyrays, says the company. It is also being used in an experimental O-ring.

Disogrin's biggest problem is heat—the material can only go to 270 deg F. However, the company reports it is working on new compounds that promise to be more heat resistant without any loss in resiliency, abrasion resistance, or tear and tensile strength. Write in No. 51 on Reader-Service Card for more information.



space | aeronautics

product of the month



ANGLE MEASURING SYSTEM has continuous decimal display



AUGUST 1959

Norden Div., United Aircraft Corp., Wiley St., Milford, Conn., working with Colorado Research, of Bloomfield, Colo., has developed an electromechanical angle measuring system that provides a continuous decimal display of the measured angle in degrees and thousandths of degrees. The BRL-5, sponsored by the Army's Ballistic Research Labs, is a high precision system giving continuous shaft angle information to a resolution of

360,000 parts in a single turn. The system consists of a small transducer and a set of electronics; its output is in decimal and 8-4-2-1 binary-coded decimal form. An in-line decimal display is also provided.

Vernier signals are produced by two tone generators in the transducer, one of which is attached to the input shaft. The phase shift between the two signals is measured on a continuous basis.

Write in No. 100 on Reader Service Card

This award is made in recognition of outstanding service performed through the development and manufacture of a product contributing to the advancement of Rudolph Hawthome the aerospace industry.



product preview

BONDING TESTER is highly versatile



This dynamometer, combined with a screw jack and materials found in almost any metal-working shop, provides an efficient tensile tester easily and inexpensively. The portable instrument measures the strength of resinous materials, such as asphalt or concrete; or any sheet material, such as metal, wood, or fiberglass; or to test the holding power of glues, mortars, or mechanical fasteners, says W. C. Dillon & Co., Inc., Dept. S/A, 14620 Keswick St., Van Nuys, Calif.

The testing assembley consists of a hook with a plug that is anchored within or on the underside of the material to be tested, and a dynamometer integrated with a screw jack.

Write in No. 165 on Reader Service Card

SERVOMOTOR is 1.355 in. long

This size 8 Inertia-Damped Servomotor weighing two ounces and measuring 1.355 in. long is specifically designed for acceleration and deceleration damping in subminiature systems without loss in steady state velocity. The unit permits use of a rotor having an inertia of 0.24 gm. cm². With the stall torque of 0.25 oz in. this produces acceleration at stall of 73,500 rad/sec2. Hence, response to input signal, upper corner frequencies approaching 45 cps are attained, says Helipot Div., Beckman Instruments, Inc., Dept. S/A, Fullerton, Calif.

No-load speed is 6,000 rpm; flywheel inertia is two gm.cm.², and the flywheel damping factor is 40 dynecm-sec/rad. Power input is 2.6 W per phase. It is said to pass any humidity procedure or combination of procedures of MIL-E-5272A and will withstand shock loads to 100 g's and vibrations of 30 g's to 2,000 cycles in all major axes. Ambient temperature range is from -55 to 130 deg C.

Write in No. 166 on Reader Service Card

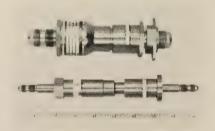
CENTER GRINDING precision machine

A high precision center-grinding machine for finishing center holes uses a cone-shaped grinding wheel that is reciprocated in a direction parallel to the center hole surface. This is said to enable all necessary movements for generation of accurate center holes simultaneously performed by the grinding cone, according to High Precision Products, Dept. S/A, 142 Greenwood Rd., Westfield, N.J.

Center holes or seals in hollow shafts of up to 2" internal diameter can be ground. Cones of 34", 11/4" and 134" are available.

Write in No. 167 on Reader Service Card

FUEL CONNECTORS for interstage use



This fuel connector is used between stages on missile plumbing systems. It has flush valves for minimum spillage. When stages connected, coupling is open; when stages separate, coupling is sealed. Low pressure drop and is available in all sizes; compatible with most fuels; positive disconnect and connect; standard AN/MS ends and customer specials, says E. B. Wiggins Oil Tool Co., Inc., Dept. S/A, 3424 E. Olympic Blvd., Los Angeles 23, Calif.

Other applications include fuel clusters in jet engine test cell; manifolding; and bulkhead fuel connector for fuselage break.

Write in No. 168 on Reader Service Card

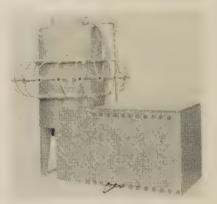
VACUUM GAGE sensitive in 2 ranges

A thermal-conductivity-type constant-temperature vacuum gage is said to have sensitivity in two ranges, from 1 micron to 100 microns and from 1 micron to 500 millimeters. Designated the "Magnevac," it has the "broadest pressure range available in any thermal-type vacuum gage now produced," according to Consolidated Electrodynamics Corp., Dept. S/A, 1775 Mt. Read Blvd., Rochester 3, N.Y.

No perishable components, such as electron tubes, are used.

Write in No. 169 on Reader Service Card

FURNACE calibrates thermocouples



Designed for use in calibrating various types of thermocouples used in aircraft and missile testing, this thermocouple calibrating furnace, teamed with a Missimers low temperature bath system, will calibrate up to 20 thermocouples simultaneously within a range of -260° F to +2005° F. The use of a Missimers low temperature bath system maintains a uniform ±0.1° F. during a 15-second test cycle in a constant temperature zone where the test thermocouples are located. Actual test temperatures are held within ±5.0° F. of any set point, says Pacific Scientific Co., Dept. S/A, P. O. Box 22019, Los Angeles 22, Calif.

Flexible automatic programing for the furnace is provided by a curve-follower strip chart programmer

Write in No. 170 on Reader Service Card

TOGGLE SWITCH is subminiature

A subminiature four-way toggle switch that mounts in less than 2%" square is called the Unimax Type 83B2-1. It combines multi-circuit control, single-hole panel-mounting, and a toggle actuator, with subminiature size. Assembly comprises eight USM5 switches, secured in a mounting bracket, with a four-way toggle mechanism. The ¹⁵%2-32 threaded bushing permits single-hole mounting in panels up to ¼" thick.

panels up to ¼" thick.

The toggle is maintained in center position and is spring-returned from each of the four "operate" positions. Each position actuates two single-pole, double-throw switches, says, W. L. Maxson Corp., Unimax Switch Div., Dept. S/A, Ives Road, Wallingford, Conn. The switches meet Mil-S-6743 and MS-25085-1.

Write in No. 171 on Reader Service Card more on page 188

TESTING AT

o F

AND ONLY "LUKEWARM"

CREEP AND STRESS RUPTURE TESTING MACHINES

HYDRAULIC FATIGUE TESTING MACHINES

HYDRAULIC UNIVERSAL TESTING MACHINES

UNIVERSAL SCREW POWER
TESTING MACHINES

As elevated temperature ranges continue to climb, needs are created for complete systems of equipment capable of testing physical properties of materials at high temperatures.

NOW — from *one* source, ready-to-operate systems incorporate all of these components:

- I. BASIC TESTING MACHINE
- STRAIN MEASURING INSTRUMENTATION for atmosphere, controlled atmosphere and vacuum furnaces
- 3. COMPLETE HIGH TEMPERATURE ACCESSORIES including furnaces, temperature controllers, vacuum pumps and complete related instrumentation.

With testing temperatures up to 4000°F currently available, Riehle engineers expect to announce a new higher range in the near future.

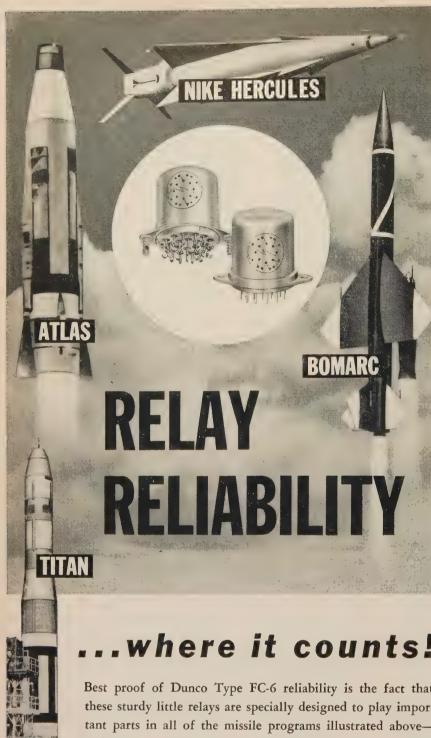
For saving time on vital projects, rely on RIEHLE. Contact us regarding your requirements for physical testing at elevated temperatures.

Riehle TESTING MACHINES

A DIVISION OF

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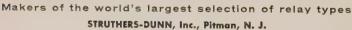


.where it counts!

Best proof of Dunco Type FC-6 reliability is the fact that these sturdy little relays are specially designed to play important parts in all of the missile programs illustrated aboveand several more besides.

Type FC-6 Relays are spotlessly clean. They have a new and outstandingly dependable contact material, and include unique design features that provide positive protection against extreme vibration and shock.

Dunco Bulletin FC gladly sent on request



Sales Engineering Offices in: Atlanta · Boston · Buffalo · Chicago · Cincinnati · Cleveland · Dallas · Dayton · Detroit · Kansas City · Los Angeles · Montreal · New Orleans · New York · Pittsburgh · St. Louis · San Francisco · Seattle · Toronto Member, National Assn. of Relay Manufacturers

Write in No. 102 on Reader Service Card at start of Product Preview Section

VELOCITY PROBE for pitch sensitivity

A cylindrical probe in sizes as small as 1/8", used to measure total pressure, static pressure and yaw angle at any point in an air stream, is supplied with its own calibration curve and is insensitive to pitch angle up to 15° from normal to the axis of the probe, says United Sensor & Control Corp., Dept. S/A, Box 127 Glastonbury, Conn.

It is useful chiefly in measuring the velocity and flow directions in liquids or gases in such applications as pumps

and turbines.

Write in No. 172 on Reader Service Card

SERVO AMPLIFIER is transistorized



The Model 1800-0300-4 Tramp is a hermetically sealed, plug-in transistor servo amplifier designed for use with a servo or synchronous motor load, says M. Ten Bosch, Inc., Dept. S/A, 80 Wheeler Ave., Pleasantville, N.Y. The 13/16x111/16x311/16-in. unit weigs eight oz.

It will deliver up to 13 W continuously, and will accept input signals from sources such as synchro control transformers, tuning fork oscillators, and electrical bridges. Environmental temperature range is -55 to +71 deg C.

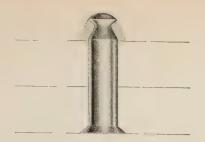
Write in No. 173 on Reader Service Card

AC TACHOMETER has shaded windings

This reversible shaded-pole motor fulfills the requirements of an ac tachometer or rate generator, with rated ac voltage applied to the main winding, a voltage is generated in the shading windings which is proportional to the speed at which the rotor is driven, says Barber-Colman Co., Dept. S/A, Rockford, Ill. Voltage is nearly linear from 1000 to 3000 rpm.

Generated voltage from a typical AYAE rate generator with low impedance shading coils (150 ohms) is two volts per thousand rpm and can be increased to ten volts per thousand using shading coils of higher impedance.

Write in No. 174 on Reader Service Card





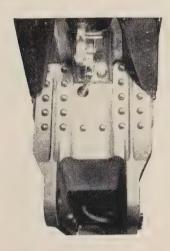
F4H-1 STRUCTURE AGAIN PROVES RIVET VERSATILITY

The Navy's next generation fighter...the McDonnell F4H-1 flies at better than twice the speed of sound, has a greater range than any Navy turbojet fighter and can operate day or night in any weather as an interceptor in an attack role.

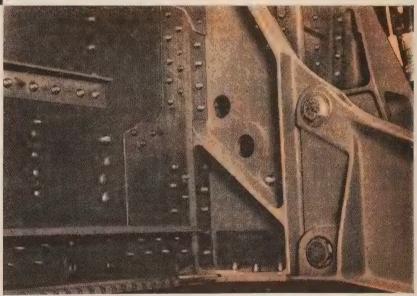
Structurally, the F4H-1 posed a variety of critical fastener problems...high strength/min. weight requirements, elevated temperatures in structures adjacent to the two J79 engines and afterburners, compactness of forging and fitting design, fatigue and vibration conditions...all met by Hi-Shear rivets, extensively used throughout the fuselage, wings and empennage.

The Hi-Shear rivet, service proven over the years in high performance aircraft and missiles, can answer similar problems for you... match the weight and installed cost of the Hi-Shear rivet with any other comparable swaged fastener.

Today Hi-Shears can meet temperatures to 1200° F., are available in sizes from ½8 thru ¾ diameters and come in materials including 7075-T6, alloy steel titanium, 5% chrome die steel, A286 alloy along with 431, 302 and 17-4PH stainless.



ATTACHING THE ARRESTING HOOK FITTING TO THE KEEL ARE TYPE 431 STAINLESS STEEL HI-SHEAR RIVETS, HEAT TREATED TO 125,000 PSI SHEAR, WITH DIAMETERS TO .0005 TOLERANCE. WHILE SUBJECTED TO 600° F. ENGINE TEMPERATURE ON THE F4H-1, THESE RIVETS HAVE A USEFUL RANGE TO 900° F. HI-SHEARS IN OTHER MATERIALS ACCOMMODATE TEMPERATURES UP TO 1200° F.



WING MAIN CARRY THROUGH FORGINGS ARE FASTENED WITH ALLOY STEEL HI-SHEAR RIVETS, HEAT TREATED TO 160,000-180,000 TENSILE. WEIGHT CAN BE CUT THROUGH SIZE REDUCTION IN YOUR FITTING OR CASTING DESIGN BECAUSE HI-SHEARS OCCUPY LESS SPACE AND REQUIRE LESS TOOLING CLEARANCES THAN COMPARABLE FASTENERS.

CONTACT YOUR ENGINEERING STANDARDS GROUP OR WRITE TO US FOR ADDITIONAL DATA ON HI-SHEAR RIVETS, HI-LOK FASTENERS, HI-TORQUE BOLTS ALONG WITH BLIND BOLTS AND NUTS.

"HI-SHEAR" TRADEMARK REGISTERED U. S. PAT OFFICE. U. S. PATENTS 2,355,579; 2,355,580. D-138-579; OTHER U. S. AND FOREIGN PATENTS PENDING.



RIVET TOOL COMPANY

2600 WEST 247TH STREET, TORRANCE . CALIFORNIA



on airborne accessories with...

LONG-LOK

self-locking screws

Per MIL-F-18240

Critical weights and needless and costly man-hours of assembly time are being saved through the use of LONG-LOK Self-Locking Screws on pressure switches, motors, pumps, valves and other airborne accessories.

Many companies in the aircraft, missile and rocket fields are using LONG-LOK Self-Locking Screws per the requirements of MIL-F-18240 to simplify their assemblies.

LONG-LOK Self-Locking Screws are heat, vibration, shock and impact resistant. They are reuseable and can be head marked for self-lock identification per specification. Increased reliability of component and system is assured.

LONG-LOK Self-Locking Screws are solving new fastener problems every day. They could be the answer to your needs.

Write for Catalog LL-59.



LONG-LOK CORPORATION

2601 COLORADO AVENUE • SANTA MONICA, CALIFORNIA
Write in No. 104 on Reader Service Card

SELF-LOCKING NUT withstands high pressures

A line of low-height, self-locking hex nuts for use on the new 160,000-psi short-thread NAS screws and bolts has been designed by Kaynar Mfg. Co., Inc., Dept. S/A, Box 2001, Terminal Annex, Los Angeles 54, Calif. Units in the Kaylock H14 Series are reported to be up to 40 per cent lighter than the lightweight self-locking hex nuts currently produced for 125,000-psi AN bolts.

The new line, which meets tensile requirements of MIL-B-7873 and MIL-N-25027, incorporates a patented self-locking design in which the upper threaded portion of the nut is deformed elliptically to produce self-locking action. Standard Kaylock anchor, miniature anchor and gang channel nuts have been redesigned to the strength level of the Hl4 Series.

Write in No. 175 on Reader Service Card

SYNTHETIC FIBER non-woven felt

A non-woven felt made of synthetic fibers has proved superior to felts of natural fibers in "virtually all significant characteristics" and is applicable in the aviation and electronics fields as insulating material; mounting for aircraft parts and hardware, and vibration suppression medium. It is also used as a filtering medium, as hydraulic and pneumatic seals and as gasket material, says Troy Blanket Mills, Dept. S/A, 200 Madison Ave., New York 16, N. Y. The product is called Troyfelt.

Other features are said to be: Higher strength, up to 1500 lbs per sq. in., dimensional stability in the presence of high temperatures (may be used continually at 400 F); better resistance to abrasion than natural fiber felts; resistant to most acid and alkalis.

Write in No. 176 on Reader Service Card

MINIATURE CONTACTS for re-entrancy

Embodying an advanced design principle, this new type Remi Re-entrancy Miniature Contacts can be removed or replaced easily with pliers or by hand. The unit employs metallic sleeves with long cantilever springs for ease of insertion, withdrawal, and operational stability, providing the optimum in re-entrancy or closed entrancy performance, says U.S. Components, Inc., Dept. S/A, 454 E. 148th St., New York 55, N.Y.

Additional plus features of the unit are: mechanical stresses are confined between metallic elements; additional polarization and keying can be accomplished with ease by use of dummy pins; contact is removed from the wiring side without disengaging connector.

Write in No. 177 on Reader Service Card

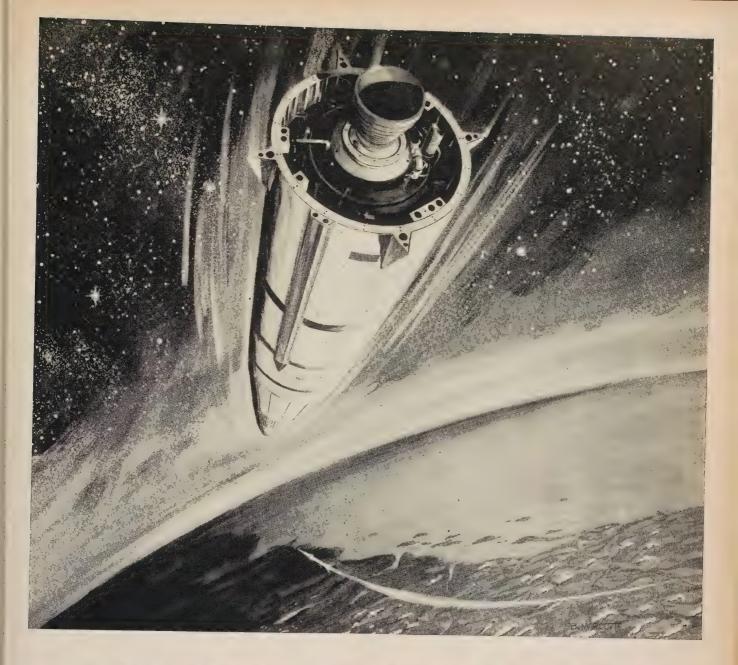
TIME DELAY RELAY is adjustable, flexible

This Type 471 Time delay relay provides an accurate, adjustable time delay between the operation of a control circuit and the subsequent transfer of one or two load switches. Through selection of external wiring connections, the unit offers broad application flexibility and "excellent accuracy at moderate cost". Typical uses include control of machine tools, batch processes, heat treating, automatic mixers, eletronic devices, and signaling equipment of many types, says Cramer Controls Corp., Sept. S/A, Centerbrook, Conn.

Time ranges from 15 seconds to 24 hours. Adjustment ranges from about 10% to 100% of full scale.

Write in No. 178 on Reader Service Card

more on page 192



INTERCEPT

Solar's creative missile team helps solve one of America's most vital defense problems

MISSILE DEFENSE involves the interception and destruction of a relatively small target travelling through space at over twenty thousand feet per second...within minutes after it is launched.

The government's Advanced Research Projects Agency has assigned Solar the task of working out a solution to an important part of this pressing military problem. This important new study contract, awarded as a result of a unique new approach to missile defense devised by Solar's creative weapon systems team, will require the very best engineering imagination and know-how. It will result in an important forward step in missile science.

With years of active experience in the many phases of missile and space technology, Solar is particularly qualified to help solve *your* design, development and pro-

duction problems. For detailed information about Solar's proven problem-solving skills, write to Dept. G-134, Solar Aircraft Company, San Diego 12, California.



ENGINEERS WANTED! Challenging projects, unlimited opportunities with Solar. Write today!

Write in No. 105 on Reader Service Card at start of Product Preview Section

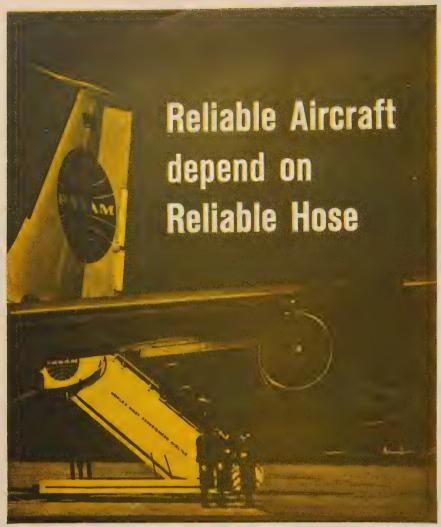


Photo courtesy Pan American World Airways.



Modern military jets have proven Fluoroflex-T (Teflon) hose in rugged service. Now the fast new commercial airliners use this same hose—for safety and economy.

Fluoroflex-T hose, with patented, specially compounded tube of Teflon, is non-aging—has no shelf or service life limit. Originated by Resistoflex, Fluoroflex-T was the first Teflon hose and it has been flying for five years on all types of jet and reciprocating engines and aircraft. It is available with compression-type fittings or "Seal-Lock*" reusable fittings.

Always specify the hose with highest performance and capabilities—not only for safety's sake, but for savings as well. Send for details. Write Department 288 RESISTOFLEX CORPORATION, Roseland, New Jersey. Other Plants: Burbank, Calif.; Dallas, Tex.

*T.M., Pat. No. 2,853,319

Fluoroflex is a Resistoflex trademark, reg., U.S. pat. off.
Teflon is DuPont's trademark for TFE fluorocarbon resins.

Pesistoflex

Write in No. 106 on Reader Service Card at start of Product Preview Section

SYNCHROS for high temperatures

High temperature synchros in sizes 11 and 23 frames are being manufactured in the 115 v torque transmitter and control transformer types, says Bendix Aviation Corp., Dept. S/A, South Montrose, Pa. The size 11 Synchro can withstand 450° F ambient temperature and meets the normal Mil-S-2335 requirements as to accuracy, etc.

The size 23 Synchro can withstand ambient temperature of 350° F.

Write in No. 179 on Reader Service Card

AIRCRAFT CONTROL as building-block kit



This standard aircraft control provides an "infinite number" of settings with precise, no-friction holding in building-block units for single or multiple lever applications. Mounting attachments use standard holes patterns and lever travel meets or exceeds other standard designs. The building-block components consist of a one-unit quadrant, input and output lever or pulley plus locking shoes; two end mounting plates; bezels; spaces and mounting rods; and three types of knobs, says Reid Metal Products, Inc., Dept. S/A, 2021 N. Lincoln St., Burbank, Calif.

coln St., Burbank, Calif.

Handles are straight, but they can be bent or cut to special lengths.

Write in No. 180 on Reader Service Card

GEAR BOX is highly versatile

An adaptable gear box provides a choice of gear reductions from 1:1 to 3125:1. Unit may be assembled in an almost unlimited number of gearing configurations from stocked shafts, gears, antibacklash gears, and slip clutches. Standard shafts provide extensions on both sides and at any of the intermediate gear passes, according to Precision Mechanisms Corp., Dept. S/A, 577 Newbridge Ave., E. Meadow, N. Y.

Constructed of anodized aluminum alloy and stainless steel, it meets Mil-E-5400. Diameter is 2.875", length 1.090".

Write in No. 181 on Reader Service Card more on page 194



AN ENTIRELY NEW CONCEPT IN PRESSURIZATION AND COOLING... A Nose cone cooling, B Cabin pressurization and cooling, C Suit pressurization and cooling, D System control, E Heat exchangers, F Electronic bay (cooling and inerting), G Supply valve, H Nitrogen relief valve, I Liquid nitrogen storage tank, J Liquid nitrogen vent valve, K Liquid nitrogen filler valve, L Helium vent and buildup valve, M 2-stage helium regulator, 4400-65 psi, N High pressure helium storage, O High pressure helium filler valve, P Helium relief valve.

• The AiResearch Pressurization And Air Conditioning System in North American's X-15 is a radical departure from normal pressurization and cooling techniques, also pioneered by AiResearch, which up to now have utilized outside air surrounding the aircraft. When the X-15 manned spacecraft climbs into space beyond the earth's atmosphere, it will carry its own atmosphere in the form of liquid nitrogen dispensed through a self-suf-

ficient AiResearch pressurization and air conditioning system for the pilot and vital equipment.

X-15 applications include: pressurizing and ventilating the cockpit and the pilot's flight suit inside of which he breathes pure oxygen; cooling and pressurizing electronic equipment and inerting its environmental atmosphere; cooling the plane's nose cone; and, operating pneumatic equipment.

High pressure helium gas is metered

to a flexible expulsion bladder forcing nitrogen out of the storage tank, insuring a normal flow at all times.

From the B-29 to the modern jet airliner and now the X-15, AiResearch pressurization and cooling of these history-making aircraft exemplify the company's continued world leadership in the pioneering and advanced development of pressurization and refrigeration systems for high altitude, high speed flight. Your inquiries are invited.



Los Angeles 45, California · Phoenix, Arizona

Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS
Write in No. 107 on Reader Service Card at start of Product Preview Section

August 1959 193





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STANDARD CHARTS... over 15,000

Read the pulse of heat, flow, pressure... whatever vital stream you check, whatever "make" your meter is, you'll act fast with facts on technical charts... write NOW for info!

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Subsidiaries of Graphic Controls Corporation

Write in No. 108 on Reader Service Card at start of Product Preview Section

BALL VALVE has metal-to-metal seats



This Venturi-Flow ball valve line has the features of metal-to-metal seats and minimal envelope dimensions. Having no clastomeric seals, this design is finding application particularly in fluid systems employing corrosive fluids and fuels. The venturi-like configuration of its flow passage permits use of a small ball, minimizing overall size and weight, says Waldorf Fluid Systems, Dept. S/A, Wolf Hill Road, Huntington Station, N.Y.

Hand, solenoid, and motor-operated versions are available.

Write in No. 182 on Reader Service Card

CONSTANT SPEED DRIVE has high efficiency

This Differential Type Constant Speed Drive combines accurate speed control, high efficiency, low heat rejection and exceptional reliability, says Vickers Inc., Dept. S/A, Detroit, Mich. The unit combines standard hydraulic pumps and motors with planetary garing to produce a compact and lighter package. Various power ranges and speed ranges are provided by changing the standard hydraulic units. Units for 60 kva output are available now. The present size range is from 20 to 90 kva.

Normal steady stat speed control accuracy of the 60 kva is ± 0.25 per cent over an oil temperature range of 200 deg F; efficiencies run to 97 per cent. Recovery from full load transients is 0.5 sec or less over a 400 deg temperature range. The drive operates successfully in any attitude. It is direct engine driven and can be either engine pad mounted or universal shaft driven.

Write in No. 183 on Reader Service Card more on page 196

WHY Ostes MEANS HIGH ACCURACY

For Missile Guidance Systems . . . Highly Accurate Precision Motor Tach Generators Utilizing Thermister Networks for Temperature Compensation.

- Calibrated to near 0° phase angles.
- Constant output from -55°C to +150°C.
- Manufactured from alloys with extremely low temperature coefficients.
- Mass produced under exceptionally rigid quality control

One reason why Oster units have high accuracy:



This Test Stand handles 12 units simultaneously, all temperature compensated to -55° C to $+150^{\circ}$ C. Also tests output voltage, phase shift and linearity. Test Stand has a speed accuracy of .01%, transformation accuracy of .001% and phase shift accuracy of 2 minutes.

For your exacting space age requirements, specify Oster motor tach generators.



New 16-page MOTOR TACH GENERATOR CATALOG No. 6000.

Lists 20 basic types for military, scientific and industrial applications. Request your free copy today — on company letterhead, please.

OTHER PRODUCTS INCLUDE:

Servos Synchros Resolvers

DC Motors

Computera
Indicators
Servo Mechanisms
Servo Torque Units



MANUFACTURING CO.

Your Rotating Equipment Specialist

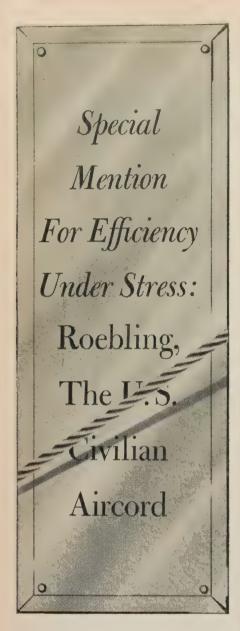
Avionic Division Racine, Wisconsin

EASTERN 310 Northern Bird. - Great Neck, Long Island, New York WESTERN 5335 South Sepulvide Bird. - Culver City, California OFFICE Phone: HUnter 7-9030 - TWX Great Neck N. Y. 2850 OFFICE Phone: EXmont 1-3142 - Taxas 2-1194 - TWX S. Man. 7517

Engineers For Advanced Projects: and servo mechanisms.

Interesting, varied work on designing transistor circuits and servo mechanisms.

Contact Mr. Robert Burns, Personnel Manager, in confidence.

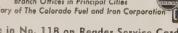


Roebling Aircord-tinned or galvanized carbon steel - comes to you bearing an unparalleled "research pedigree." It is built and tested to exceed military specifications: constructional stretch has been virtually eliminated. Roebling makes Lock-Clad Aircord (aircraft cable with aluminum tubing swaged around it), stainless steel aircord, assemblies with fittings swaged to cable ends, as well as a complete line of slings.

Plane manufacturers and air supply houses interested in the qualities of Roebling aircord assemblies or slings, may address inquiries to Wire Rope Division, John A. Roebling's Sons Corporation, Trenton 2, N. J.

ROEBLING

Branch Offices in Principal Citles
Subsidiary of The Colorado Fuel and Iron Corporation



VARIABLE DRIVE for precision setting



This variable speed drive for exact adjustment to any speed setting or duplication of previous settings can be furnished with an accurately-calibrated, vernier, ten-turn dial. The 2" square model of the "Servotran" is no larger than an ordinary gear box and can provide output shaft speeds infin'tely variable from 0 to 1200 rpm forward and reverse. This model is available with motors in the 1/100to 1/40 hp range. A larger model is for applications requiring 1/40 to 1/10 hp and a smaller for the 1/1000 to 1/100 hp range, says Humphrey, Inc., Dept. SA, 3794 Rosecrans St., San Diego 10, Calif.

By substituting a direct acting lever for the dial, the drive may be shifted from full forward to full reverse in .05 sec.

Write in No. 184 on Reader Service Card

DISCONNECT VALVE for cooling water



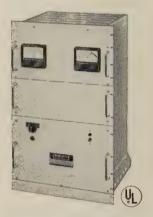
This missile cooling water disconnect valve is both non-conducting and heat-resistant owing to the use of nonmetalic components. The valve provides zero leakage shutoff for two lines and opens a vent port during separation. The socket body is of glass filled epoxy resin, reducing interference with adjacent electronic equipment, according to Symetrics, Inc., Dept. S/A, 3100 Airport Ave., Santa Monica, Calif.

Other specifications include: weight .30 lbs; proof press 250 psi; temp. -65° to 200° F.; cont. 1000° F for 30 sec.; press drop 1 psi @ 1.5 gpm; and disconnect force 1.5 lbs.

Write in No. 185 on Reader Service Card more on page 198

D-C POWFR

Precisely Regulated for Missile Testing and General Use





SILICON POWER SUPPLIES

available in 30 standardized and militarized models from 30 to 1500 amps... 6 to 135 volts. CHRISTIE'S **OUALITY CONTROL is** approved by the A.E.C., leading aircraft and missile manufacturers.

Write For Bulletin AC-58-A

CHRISTIE ELECTRIC CORP.

3410 W. 67th Street Los Angeles 43, Calif.

Write in No. 285 on Reader Service Card SPACE/AERONAUTICS



This "bubble" owes its complexion to Polyken tape

MOT A SCRATCH . . . NOT A DENT . . . THANKS TO THE MODERN METHOD OF SURFACE PROTECTION

The cockpit canopy of a fighter plane can be easily scratched during manufacture. So makers of supersonic aircraft take no chances. They protect its relatively "soft" surface with pressure-sensitive tape.

Not just *any* tape, though. Canopies are too valuable for that. Throughout handling and storage, they're covered with special Polyken tape.

Whatever surfaces you want to protect (from soft plastic to tough steel), there's a Polyken tape that unwinds easier, conforms better, gives superior surface protection, and pulls off clean.

THE MODERN TOOL ... AT WORK FOR MODERN INDUSTRY



face-protection problem
—check with the Polyken Industrial
Tape Distributor nearest you, or write to
the Polyken Sales Division, 309 W. Jackson
Blvd., Chicago 6, Illinois. Dept. SA-8.

Polyken

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Polyken Sales Division





PRESSURE INDICATORS & TRANSMITTERS

DELIVERY FROM STOCK

MS-28005 Synchro Pressure Transmitters



•	MS No.	Part No.	MIL Spec.	Range	Function	Use with Indicator	
3	MS28005-1	7709-15-B5-1	MIL-T-5882	0-50 PSI	Multi-purpose	MS28010-1	
	MS28005-2	7707-30-D5-1	MIL-T-5796	0-100 PSI	Oil	MS28010-2	
***************************************	MS28005-3	7707-2-C5-1	MIL-T-5790	0-200 PSI	Oil	MS28010-3	1
***************************************	MS28005-4	Gage Pressure Available	MIL-T-5396	0-1000 PSI	Fuel	MS28010-4	
	MS28005-5	7609-37-C5-1	MIL-T-7113	0-4000 PSI	Hydraulic	MS28010-5	
	MS28005-6	7710-9-B7-1	MIL-T-5780	10-75" Hg	Manifold	MS28010-6	1
	MS28005-7	Linear Calibration Available	MIL-T-6302	0-600 PSI	Fuel	MS28010-7	, .

MS-28010 Synchro Pressure Indicators



,	MS No.	Part No.	MIL Spec.	Range	Function	Use with Transmitter
,	MS28010-1	25201-A15B-4-1-B2	MIL-1-7085	0-50 PSI	Multi-purpose	MS28005-1
	MS28010-2	25101-A30E-1-C1	MIL-I-7086	0-100 PSI	Oil	MS28005-2
	MS28010-3	25101-A2C-1-C1	MIL-1-7087	0-200 PSI	Oil	MS28005-3
	MS28010-4	25101-A27C-1-C1	MIL-1-7088	0-1000 PSI	Fuel	MS28005-4
, ,	MS28010-5	25101-A37B-1-C1	MIL-1-7084	0-4000 PSI	Hydraulic	MS28005-5
A	MS28010-6	25101-A9B-1-C1	MIL-1-7089	10-75" Hg	Manifold	MS28005-6
-14	MS28010-7	25101-A43B-1-C1	MIL-I-6301	0-600 PSI	Fuel	MS28005-7



Guide to Military and Commercial Autosyn* Synchro Indicators, Autosyn* Synchro Transmitters, Aircraft Pressure Switches.

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Montrose Division

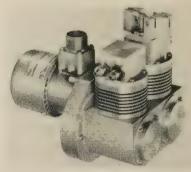
SOUTH MONTROSE, PA.



Write in No. 111 on Reader Service Card at start of Product Preview Section

PRODUCT PREVIEW

AIR-VACUUM PUMP is versatile



Convertible to compound air or vacuum by interchangeable cylinder heads, this nearly maintenance-free combination pump is a dual-piston design for simultaneous production of oil-free compressed air from one cylinder and oil free vacuum from the other. Suited for aircraft ground test equipment, instrument and accessories testing, and pressurization of electronic systems (airborne or ground), says Applied Dynamics Corp., Dept. S/A, 32 N. Main St., Natick, Mass.

Pre-lubrication of bearings and other moving parts of the Dynetics model 04-601 allows a minimum of 1,000 hours operation without lubrication; graphitar and teflon piston rings eliminate cylinder lubrication.

Write in No. 189 on Reader Service Card

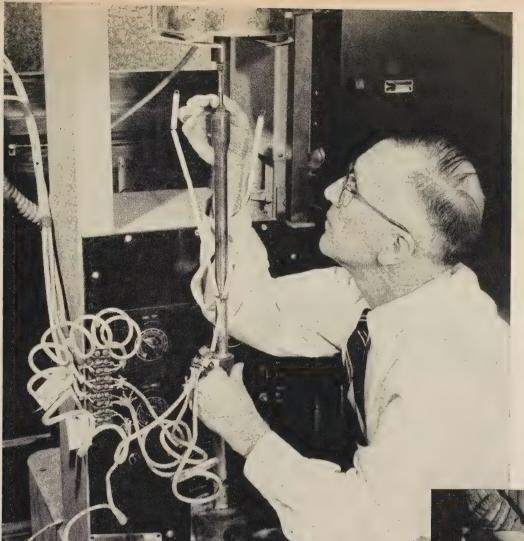
MECHANICAL BRAKE has fast response



Fast response and high braking force are featured in an electromechanical brake that is designed for emergency function in aircraft applications, says Steel Products Engineering Co., Dept. S/A, Springfield, O. The solenoid-operated brake uses 24 V dc and draws an instantaneous current of seven amps. Minimum firing voltage is 14 V.

A 200-msec reaction time, holding torque of 300 in.-lb, and automatic current cutoff after the brake is energized are among the characteristics of the 3.2-lb unit. A reset knob is used to manually release and reset the brake.

> Write in No. 190 on Reader Service Card more on page 200



Physical tests at Standard include those for special properties of steel alloys under extreme variations in temperature. Here, the strength and ductility of steel are being checked for resistance to stress under severe conditions of elevated temperatures over a prolonged period of time.

Charpy impact and transition temperature determinations have recently assumed importance in many applications. Here a steel sample is immersed in liquid nitrogen to determine its susceptibility to fracture at temperatures as low as —300°F.

Quality control—a vital activity at Standard Steel Works

Every conceivable shop and laboratory test required for modern quality control can be performed by Standard's staff of metal-lurgical technicians. Testing of incoming raw materials; physical property tests of steel and other alloys at temperatures from several hundred degrees below zero up to red heat; gas analysis, ultrasonic, X ray, magnetic particle, fluorescent penetrant and microscopic examination of finished products are routine checks which assure that the finished, delivered product will meet the most rigid specifications. Write Department 6-H for full details.



Standard Steel Works Division

BALDWIN · LIMA · HAMILTON

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Rings • Shafts • Car wheels • Gear blanks • Flanges • Special shapes



When You Do It Yourself





start with

The Best In Teflon

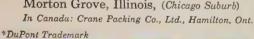
It's a matter of good precaution—Getting the full advantages of this material depends largely on the processing ability of your supplier. He must meet all of these qualifications:

- Fabricating experience, facilities and rigid quality control to supply a uniform, non-porous Teflon, free from any flaws, thus eliminating costly rejects or malfunction of your end product.
- Dimensional accuracy—no matter what form you order, it should be carefully sized to industry specifications. Any waste of Teflon adds substantially to its cost, and corrective finishing in your own shop unnecessarily adds production time and expense.

Under the name, Chemlon, "John Crane" gives you full satisfaction on each of these points, plus engineering assistance on any problem you might have.

Contact "John Crane" about your specific needs. Also ask for Bulletins T-110 and T-122.

Crane Packing Co., 6439 Oakton Street, Morton Grove, Illinois, (Chicago Suburb)













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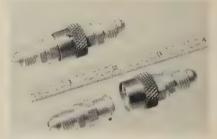
SPEED CONTROL VALVE reduces contamination

A combination needle and ball-check valve, called "Vari-Speed," is used to control the speed of a single or double-acting air or hydraulic cylinder by restricting flow from the exhaust end of the cylinder during piston movement in one direction. Opposite movement unseats the ball check and bypasses the needle-valve section, says Control Line Equipment, Dept. S/A, 19560 Center Ridge Rd., Cleveland 16, Ohio.

The aluminum valve bodies withstand pressures to 2000 psi. All other parts are stainless steel.

Write in No. 191 on Reader Service Card

MINIATURE COUPLING is self-sealing



This miniaturized 1010 Series Coupling is 2½" long and weighs slightly over ½ oz. Connection is by a bayonet-type lock and each half is self-sealing with Viton A "O" rings. Suitable for electronic cooling systems, test stand, filling and charging connections, pressure sensing and other general aircraft or missile applications where lightweight and compactness are desired, says Aeroquip Corp., Dept. S/A, Jackson, Mich.

Exceeds requirements of Mil-C-7413 and has an operating temperature range of -65° to +375°% with operating pressures to 1500 psi.

Write in No. 192 on Reader Service Card

IMMERSION PUMP is efficient

This Immersion Pump, HP-8, can deliver 11,000 scfh of nitrogen. It is a reciprocating, single-action, positive displacement type pump designed for storage tank operation. It is the most compact and lightest pump of its type on the market and hence can be immersed in a tank eliminating the need for a sump, says Linde Co., Dept. S/A, 420 Lexington Ave., New York 17, N.Y.

This pump gives about 30 per cent greater volumetric efficiency than any other reciprocating pump on the market, it is claimed.

> Write in No. 193 on Reader Service Card more on page 202

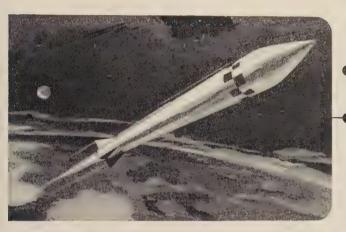
Historical Achievements at JPL



JATO UNITS...The nation's first successful jet-assisted takeoff (JATO) units were originated and developed in 1941 at the Jet Propulsion Laboratory, and sparked the development of future rocket vehicles.



THE WAC-CORPORAL...fired in flight from a V-2 rocket, established a world's altitude record of 250 miles in 1949. The combination was known as the Bumper-Wac.



THE CORPORAL...this country's first ballistic surface-to-surface guided missile, now an operational weapon of the U.S. Army, was pioneered and developed by the Jet Propulsion Laboratory.



THE SERGEANT...A second-generation solid propellant missile developed by JPL for the U.S. Army. The SERGEANT is now being readied for production.



EXPLORERThe United States' first successful earth satellite, launched January 31, 1958, was developed by JPL in collaboration with the Army Ballistic Missile Agency.



PIONEER IV... America's first successful moon-space probe, launched March 3, 1959, was developed by the Jet Propulsion Laboratory in collaboration with the Army Ballistic Missile Agency and the National Aeronautics and Space Administration.

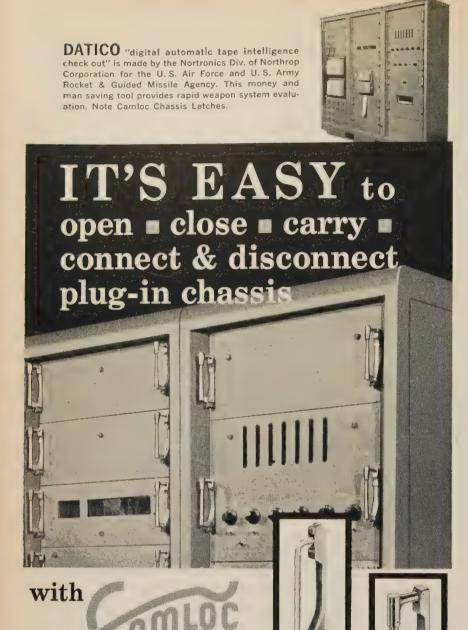
JET PROPULSION LABORATORY

A Research Facility operated for the National Aeronautics and Space Administration
PASADENA. CALIFORNIA

Employment opportunities for Engineers and Scientists interested in basic and applied research in these fields:

INFRA-RED, OPTICS, MICROWAVE, SERVOMECHANISMS, COMPUTERS, LIQUID AND SOLID PROPULSION, STRUCTURES, CHEMISTRY, INSTRUMENTATION, MATHEMATICS, AND SOLID STATE PHYSICS

Send professional resume', with full qualifications and experience, for our immediate consideration



Thirty-eight strong, simple, attractive Camloc multi-function Chassis Latches are used on the 24 equipment filled plug-in chassis that make up DATICO, the military's new universal automatic field service checkout system. Here is a perfect example of designed-in fastener serviceability, flexibility, ease of handling and economy in interconnected "black-box" systems. When the Camloc push-button handles are released and pulled down, the chassis is automatically disconnected and ejected. Then the latch becomes a carrying handle. When replacing the equipment the latch firmly pulls the chassis back in place, making perfect, automatic reconnection of multiple-pin units. It is quick, safe, reliable, vibration-proof. Camloc Chassis Latches consist of only two parts—a handle and a fork—mounted with standard screws. Several handle and fork designs are currently available, all interchangeable. Write for Camloc's new Bulletin 35L today.

multi-function

CHASSIS LATCHI

"Specialists in Fasteners for Industry"

CAMLOC FASTENER CORP. • 13 SPRING VALLEY RD., PARAMUS, N. J. WEST COAST OFFICE: 5410 WILSHIRE BLVD., LOS ANGELES, CALIF. • SOUTH WEST OFFICE: 2503 W. BERRY ST., FORT WORTH, TEXAS

See us at the WESCON Show — Booths #1106-1108

Write in No. 114 on Reader Service Card at start of Product Preview Section

PRESS for missile parts

A 2000-ton press for manufacture of rocket, missile and space vehicle components out of plastics, with 12 foot of daylight can make such parts as blast tubes, adapters, insulation, nose cones, jet vanes, jetevators, exit cones, and many other structures of molded plastics, according to Haveg Industries, Inc., Dept. S/A, Wilmington, Del.

Materials fabricated operate from 2000° to 20,000° F.

Write in No. 194 on Reader Service Card

ACCELEROMETER is miniaturized



This accelerometer, measuring 1" x 134" and weighing three ozs, designated model GMA, is suited for aircraft, missile fire, flight control systems and telemetering applications. Construction enables the model to withstand vibrational accelerations of 10g's, 10 to 20,000 cps, on any axis, and shock accelerations of 50g's for 7 ms duration on any axis, says Genisco, Inc., Dept. S/A, 2233 Federal Ave., Los Angeles 64, Calif.

The instrument is temperature compensated and will operate to specifications between -20° F and $+250^{\circ}$ F.

Write in No. 195 on Reader Service Card

RELIEF VALVE solves heat problem

The Model EA-1225 relief valve has been designed to relieve excessive thermal pressure in the branch lines of hydraulic systems in high speed aircraft, says Electrol, Inc., Dept. S/A, Kingston, N.Y. The six-oz thermal relief valve has a range of —65 to +400 deg F and conforms to the AN6245B4 envelope and all Mil-V-5527A requirements.

The device can be used in MLO (Oronite) or Monsanto OS45-1. It has a maximum rated flow of one cu in./min. It is being offered in T-, in-line, and dual types, with operating pressure ranges of 50 to 1000, 1000 to 2100, and 2100 to 4100 psi

Write in No. 196 on Reader Service Card more on page 206





POGO-HI (II E3c)



P-107 AIR LAUNCHED



GROUND LAUNCHED

AERONCA TARGET MISSILES PERFORM A VARIETY OF MISSION PROFILES ... WITH SUBSTANTIAL ECONOMY

The adage "practice makes perfect" keynotes today's concept of missile warfare. Against supersonic targets, there isn't time for "the second barrel". Therefore, extensive operational testing of air defence systems . . . and training programs for personnel who operate them . . . must be conducted to assure national preparedness.

To accomplish this requirement at minimum cost, Aeronca has developed two expendable, lightweight, high-performance target systems under the Design-Tool-Produce envelope concept. These proprietary missile programs, the P-106 and P-107, are designed for supersonic performance and accurate scoring at all required altitudes, speeds and ranges. And their production cost is projected to be substantially less than any current target missile system!

Another Aeronca-produced missile project is Pogo-Hi II E3c. Ground launched to high altitudes, this target utilizes a radar reflective parachute and an infrared emitter package. It is used as "bait" for such current projects as Nike, Talos, Sidewinder and Falcon.

> With integrated Design, Tooling and Production capabilities, Aeronca can produce weapon systems envelopes at either prime or subcontractor levels.

ERONCA manufacturing corporation 1724 GERMANTOWN ROAD . MIDDLETOWN, OHIO

Operational expansion has created openings for additional senior engineers. Write to W. W. Gordinier, Personnel Manager. Write in No. 115 on Reader Service Card at start of Product Preview Section



Knowmanship—the professional partner for prime contractors

There are associate contractors—and then there are associate contractors.

What a difference it makes in the over-all success of the "prime's" project when an associate has the necessary experience and capabilities to fit into the "team" picture smoothly—and to carry out his responsibilities efficiently.

KNOWMANSHIP is our word for describing Eclipse-Pioneer's unique qualifications in these areas. KNOWMANSHIP stands for the critical combination of technical knowledge, experienced management and special-

ized craftsmanship that we offer prime contractors.

Consider the supporting facts:

... over forty years' experience in developing and manufacturing high-precision, airborne sub-systems and components ... management experience under the Weapons System concept dating back to the very first such contract awarded and including association with such "primes" as Convair (for the Air Force), Martin



(for the Army), and Douglas (for the Navy).

Backing up this proved experience and management ability are the physical resources needed "to get the job done". These include over 9,500 skilled people and more than 1.1 million square feet of plant area.

In short, we offer you professional partner KNOWMANSHIP in advanced aircraft and missile sub-system development and production. Our representatives are at your call wherever and whenever you have a project to discuss.

69% of E-P's procurement dollars go to small business.

ECLIPSE-PIONEER BONSON OF THE BONSON OF THE



AUTOMATIC FLIGHT CONTROL ● CENTRAL AIR DATA SYSTEMS ● SPECIALIZED INSTRUMENTATION ● NAVIGATION COMPUTERS AND DIRECTORS
STABLE PLATFORMS ● INERTIAL GUIDANCE ● RADAR ANTENNA STABILIZATION AND TRACKING SYSTEMS ● GROUND SUPPORT EQUIPMENT

Write in No. 116 on Reader Service Card at start of Product Preview Section

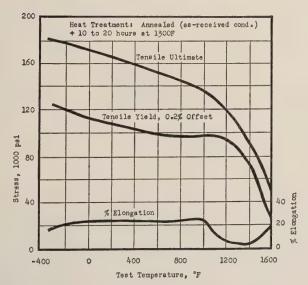


Space cold



Re-entry hot

INCONEL "X"... when you want sheet with range



Typical tensile properties of age-hardened Inconel "X" alloy sheet. Note strength at high and low temperatures. Much higher strengths are the additive effects of cold work and age-hardening.

Need sheet metal with high mechanical performance from space cold to glowing red heat?

- High impact strength down to liquid oxygen temperatures
- Room temperature tensile strength up to 220,000 psi
- 100-hr rupture life of 25,000 psi at 1500°F
- Oxidation resistance through 2,000°F

You can put all these high-performance properties into missile-age designs with Inconel "X"* age-hardenable nickel-chromium alloy sheet. See graph, left.

Favorable fabrication properties

With heat treatment, Inconel "X" sheet may be given a wide range of strengths and hardnesses. In addition, this versatile metal is formed, welded and machined by standard methods.

You can order Inconel "X" sheet in standard mill sizes. Inconel "X" rod, bar, strip, seamless tube as well. Want more information? We'll be glad to send further data at a word from you.

Inco trademark

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N. Y.

NCO NICKEL ALLOYS

Write in No. 117 on Reader Service Card at start of Product Preview Section

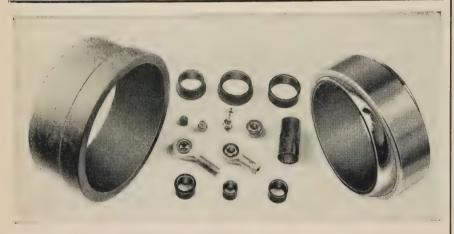
HYDRAULIC PUMP



This variable-volume vane pump built-in compensator has a built-in pressure compensator that keeps the volume at pre-selected pressures so that the pump delivers only the exact volume of oil needed. Valves and piping normally needed to bypass oil are eliminated, says Vickers, Inc., Dept. S/A, 172 E. Aurora St., Waterbury 20, Conn.

Pump is rated at a maximum volume of 5 gpm at 18,000 rpm and a maximum pressure of 1,000 psi. Available for flange, root or gasket mount-

Write in No. 197 on Reader Service Card more on page 209



SELF-LUBRICATING FABROID solve bearing BEARINGS acute bearing problems

- Lubrication and maintenance
- Extreme temperatures
- Abrading, galling, or corrosion
- Shock and vibration
- Contamination
- Tight space, weight conditions
- Static Friction

FABROID BEARINGS PROVIDE MAXIMUM LIFE FOR LOW-SPEED, HIGH-LOAD APPLICATIONS

FABROID consists of two fused layers. The bearing layer is a weave of Teflon* fibers interwoven on the back with a layer of phenolic-impregnated glass fibers of high

Bonding the two layers under pressure and elevated temperature results in a dense lattice of self-lubricating Teflon fibers which have ten times the strength of other Teflon forms.

FABROID BEARINGS:

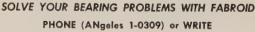
Provide—reliability, weight-saving, nearlyequal starting and running coefficients of friction

Reduce—costs, wear, maintenance, and

Eliminate—lubrication, fretting, brinelling, use of seals

FE. I. Dupont's Tetrafluorethylene

U.S. Patent Nos. 2,804,886; 2,835,521; 2.885.248





MICRO-PRECISION DIVISION

Micromatic Hone Corporation

1535 Grande Vista Ave. • Los Angeles 23, California

Write in No. 119 on Reader Service Card at start of Product Preview Section

FLEXIBLE AND MOLDED



Electronic heating harness molded to fit small object. Three woven heaters molded in high temperature refractory and aluminum case (left) and glass and polyester resin (center and right). Small thermostat is molded to base of center heater.



Neoprene rubber molded heater, eliminates ice clogging of aircraft pitot tube.



Silicone rubber laminated heater molded on a spherical radius. Two of these completely cover and protect guided missile storage battery reservoir.



Silicone rubber laminated heater bonded to a metal component for an aeronautical camera.



Woven heaters, Temperatures to $800^{\circ}F$. Any size or shape up to $24^{\prime\prime}$ wide and to any length. Can be supplied with eyelets, snap fasteners, mounting holes. Moisture and abrasion resistance can be provided by silicone rubber coating.

Chromalox Flexible and Molded Heaters are shaped-to-fit to put exact amounts of heat where it is needed.

FREE - Send today for new Bulletin J-1003 which gives detailed engineering information. Or, call your Chromalox Representative for personal assistance with any heating problem. 91812





Write in No. 223 on Reader Service Card SPACE/AERONAUTICS



In a record-breaking flight from Seattle to Rome — 5,830 miles, nonstop — the Boeing 707 Intercontinental demonstrated its prowess as the world's newest, longest-range jetliner. On its return flight, the 707 Intercontinental left London at 3:18 P.M. London time, arrived in Seattle at 3:56 P.M. Seattle time the same afternoon. This great, new Boeing jetliner goes into commercial service later this year, bringing unprecedented range, speed and comfort advantages to the airline routes of the world.



These airlines have ordered 707 and shorter-range 720 jetliners (asterisks indicate Intercontinental purchasers):
*AIR FRANCE • *AIR INDIA • AMERICAN • *B,O.A.C. • BRANIFF • CONTINENTAL • CUBANA • IRISH • *LUFTHANSA
*PAN AMERICAN • QANTAS • *SABENA • *SOUTH AFRICAN • TWA • UNITED • *VARIG • Also MATS





ARE YOU GETTING ALL THESE BENEFITS WITH YOUR MAGNESIUM CASTINGS?

Dow magnesium foundry offers experience, production capacity for sand and permanent mold castings of all sizes and shapes.

The unique capabilities of Dow's Bay City, Michigan, foundry help users of magnesium sand and permanent mold castings. Activities at this facility—largest and best equipped of its kind—run the gamut from large volume production jobs to one-shot "specials".

Huge or tiny castings. The foundry is capable of producing castings weighing in excess of 3,000 lbs. down to ounces—in all degrees of complexity. Experienced pattern engineers ensure that the best use of casting processes is made. This can result in either lower costs, improved quality, better deliveries, or a combination of all three.

Newest techniques. Many milestones in magnesium casting have been reached at this Dow foundry. In fact, Bay City has men permanently assigned to developmental work, keeping the foundry in the forefront of technological advances at all times.

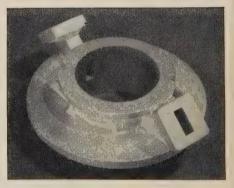
Results of their work include special processes for cast-in inserts and tubeless passages, and improved melting techniques. Casting methods have been developed for many of the newer magnesium alloys, such as the elevated

temperature group and the new high damping capacity alloy, K1A.

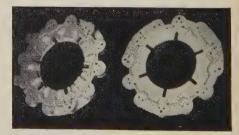
Quality control. A full time quality control team exhaustively checks all work, from alloy composition to the shipping dock. A direct-reading spectrometer makes rapid alloy composition analyses. Its speed is particularly valuable when alloying elements that are hard to hold in the molten state, such as thorium, are present. Chemical analysis is also frequently employed.

Testing facilities. Molding and sand cores are analyzed as a regular part of casting quality control. Radiography, fluorescent penetrant inspection and other testing facilities are used to check properties and specifications.

Experienced magnesium team. The foundry often draws upon the broad range of specialized experience available throughout the company. To Bay City customers, this means assurance of high quality work, done with utmost efficiency and economy. If your requirements involve magnesium castings, Dow can help you arrive at optimum casting design and reliably supply your production requirements.



THIS SAND CAST WAVE GUIDE was held to $\pm .005''$ on passageway dimensions. Surface smoothness requirements are 63 RMS. The foundry has government approval for any phases of its operations where such approvals are applicable.



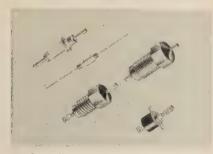
THIS BRAKE CARRIER is sectioned to show how the hydraulic lines were integrated by use of tubeless passageway casting techniques.



WRITE TODAY for this illustrated brochure discussing Dow foundry services. THE DOW CHEMICAL COMPANY, Midland, Michigan, Magnesium Product Sales Dept. 1303EW8.

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN
Write in No. 120 on Reader Service Card at start of Product Preview Section

FEED-THROUGH FILTERS have high efficiency



The efficiency of these filter elements increases with frequency, eliminating high-frequency radiation and feedback in low power circuits from 50 to 5000 mc, says Allen-Bradley Co., Dept. S/A, 136 W. Greenfield Ave., Milwaukee 4, Wisc.

The design of the elements prevents the reduction of effective capacitance due to parallel resonances, and effective filtering capacitances up to 500,000 uuf are obtained. The filters are available to 50 V dc at temperatures up to 125 deg C ambient. Maximum dc and LF currents are 5 amp. Standard maximum rf at rated dc voltage is 0.25 amp, with higher current ratings available on special order. Unit may also be supplied with cascaded elements.

Write in No. 200 on Reader Service Card

HOSE ASSEMBLIES are very flexible

These new nylon covered tygon hose assemblies with AN, MS, or special fittings are for use with oxygen and special corrosive fluids and gasses, burst pressures to 2000 psi and temperature range from -68 to +215 deg F, says Zep Aero, Dept. S/A, 113 Sheldon St., El Segundo, Calif.

They are light-weight with extreme flexibility yet allowing minimum bend radius without collapsing; excellent shelf life, it is claimed, far surpasses rubber compositions.

Write in No. 201 on Reader Service Card

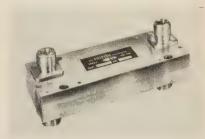
AIR DUCT JOINTS are self-aligning

The new Flexhot Air Duct Joints, patterned after the Monofall, have longer cycle life with ten degree self-aligning and 360 deg rotation, says Southwest Products Co., Dept. S/A, 1705 S. Mountain Ave., Monrovia, Calif.

The self-aligning air duct joints are available in bore size of five inch with operating pressures of 110 psi and a temperature operation of 550 deg F. Other bore sizes on request.

Write in No. 202 on Reader Service Card

HYBRID JUNCTIONS are light and rugged

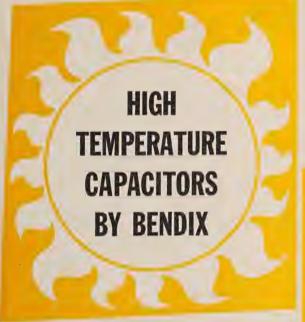


These coaxial hybrids are designed for use in duplexers, mixers, and other circuits requiring a division of power into two transmission lines. A signal into any terminal of a hybrid appears at the two opposite terminals. The two output signals are equal in magnitude but are 90 deg out of phase with each other, says Narda Microwave Corp., Dept. S/A, 118 Herricks Rd., Mineola, N.Y.

The three models cover frequencies of 460-950, 950-2000, and 2000-4000 mc, all with 3.0-db coupling ±0.25 over the entire band. All exhibit a VSWR of 1.2, with 20 db isolation. Type N female terminals are standard; Type C, TNC, BNC, or SC are available on special order.

Write in No. 203 on Reader Service Card

more on next page



DESIGN FEATURES

Temperature Range . . . -55° to +315°C. Capacitance . . . 0.05 to 4.0 uf at 600 VDC. Voltage Range . . . 600 V to 3000 V per section. No Voltage Derating, Low Capacitance and Power Factor Variation, Environmental Resistant, Hermetically Sealed, Rugged Construction, Nonstrategic Materials, Minimum Size and Weight, High Altitude Operation.

The E-315 capacitor offers proven stability of operation over the temperature range of -55° to $+315^{\circ}$ Centigrade* with no voltage derating and low capacitance variation. Of rugged hermetically sealed construction and nonstrategic materials, this capacitor is built for high altitude and severe environmental operation.

This nonpolarized capacitor is available in a variety of sizes in a capacity range of from 0.05 to 4.0 microfarads at 600 VDC. It is also available in higher voltage ratings. Performance data and operating characteristics are given in Technical Bulletin SL-61 which is supplied upon request.

*Confirmed by qualification test of 1000 hours at 100% rated voltage over ambient temperature range of -55° to $+315^{\circ}$ C.



Canadian Affiliate: Aviation Electric Ltd., 200 Laurentien Blvd., Montreal 9, Quebec. Export Sales and Service: Bendix International Division, 205 East 42nd St., New York 17, N.Y

Scintilla Division

Sidney, New York





Industrial White Airbrasive® Unit

Not that we advise doing this to your fine crystal glassware, but it seemed to us a dramatic way to show you the versatility and the cool, shockless cutting and frosting action of our Industrial Airbrasive Unit.

Cuts as fine as .008" or large frosted areas are equally easy to make with this amazing industrial tool. A gas-propelled stream of abrasive particles quickly slices or abrades, as needed, almost any hard, brittle material, such as fragile crystals, glass, oxides, metal, minerals, ceramics.

Applications range from printed circuits, wire-stripping potentiometer coils, and cleaning off oxides...to shaping or drilling germanium. Every day new uses for the Airbrasive Unit are being discovered.

> Send us your most difficult samples and we will test them for you.

SEND FOR BULLETIN 5705A...complete information.



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Western Office: 1839 West Pico Boulevard, Los Angeles 6, California

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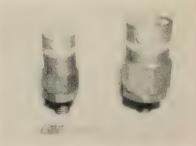
BLOWER UNIT for high altitudes

This special high-altitude blower unit, SK1991, for ventilating and cooling aircraft enclosures and electronic equipment is designed to meet all environmental conditions in MIL-E-5272A, says Torrington Mfg. Co., Dept. S/A, Torrington, Conn.

This blower unit, furnished with a totally-enclosed, explosion-proof aircraft motor rated at 1/3 hp and 27 Vdc, is recommended also for military, ground and marine service. Air delivery is 500 cfm at a static pressure of 2.4 in. of water at 65,000 ft.

Write in No. 204 on Reader Service Card

TRANSDUCER for high G



Intended for determination of high "G" accelerations and moderate velocity changes, this G 101 Peak Reading Accelerometer and Velocity Change Transducers contain an antihammering device and improvement for loading the transducer. Applications are drop impact, gun propellant systems, explosive devices, etc., says Avionic Products Engineering Corp., Dept. S/A, Dover, N. J.

The transducers are in various ranges from 2,000 G's to 60,000 G's and velocity changes from 2.8 to 95 ft. 1 second. Accuracy is approximately ±5% with natural frequencies varying between 700 and 2,500 cps.

Write in No. 205 on Reader Service Card

INDICATOR measures one inch

This new miniature one-inch indicator which meets MIL-L-25950 and is integrally lighted to MIL-L-25467-A is offered by John Oster Mfg. Co., Dept. S/A, 1 Main St., Racine, Wis. Type IND-9811-02 is filled with inert gas and hermetically sealed, has -65 to +160 deg F ambient temperature range, weighs only 3.8 oz and meets environmental requirements of MIL-E-5272A and applicable portions of MIL-I-7057.

Rotor input is 26V 400 cycles, stator output 11.8V 400 cycles and input to lamps five V 400 cycles. Air Force stock number is 6620-624-4148.

Write in No. 206 on Reader Service Card

more on page 212

This is the symbol of Aerotest's new Product Engineering Division. It stands for the same high level of service and creative engineering that has earned for Aerotest's Test Engineering Division a reputation as the leading independent test laboratory serving the aircraft and missile industry.



Major expansion of Aerotest's Product Engineering Division solves a serious problem faced by Weapon System contractors

THE PROBLEM: Increasing scope and complexity of aircraft, missile and spacecraft Weapon Systems has made it virtually impossible for contractors to locate and purchase "standard, readily available" equipment which meets their requirements. The problem is heightened by the fact that most equipment suppliers are often unwilling or unable to undertake programs that do not fit into their "standard" line of products.

As a result, contractors are forced into producing equipment at their own plants to satisfy their own needs. This means a considerable loss in efficiency plus higher costs, since the "special" project is often incompatible with the contractor's field of endeavor.

THE SOLUTION: The PRODUCT ENGINEERING DIVISION of Aerotest Laboratories, Inc. provides a proven solution. Aerotest's PED does not maintain or depend on a "standard" line of products. Instead, it offers an integrated team of Design and Production Engineers, supported by modern manufacturing facilities—available to assist you with your "special" equipment requirements, in limited or large production quantities.

We invite your inquiries to learn how creative engineering and manufacturing can change your special requirement into a PED standard project.

PRODUCT ENGINEERING DIVISION,
AEROTEST LABORATORIES, INC.
129-11 18th AVENUE, COLLEGE POINT 56, N. Y.



Special-Purpose Airborne and Ground Support Equipment for Aircraft, Missiles and Spacecraft.

Write in No. 125 on Reader Service Card at start of Product Proview Section

August 1959





KEL-F® BLADDER STORES LOX or FNA

A plastic so thermally stable it can live with liquid oxygen, so chemically inert it resists both red and white fuming nitric acid! Plastic tubing of KEL-F® halofluorocarbon polymer, a 3M Chemical, is now proving itself in expellant bladders such as that shown above. Thanks to KEL-F® properties, the bladder survives contact with LOX, WFNA and RFNA. Tests by the makers of the tubing indicate that the heat-sealed bladders may safely store their contents from 3 to 5 years, perhaps longer. In addition to

chemical and thermal stability, KEL-F® polymers exhibit zero moisture absorption, great dimensional stability with virtually no cold flow, excellent electrical and mechanical properties. Check the properties listed at the right, then investigate KEL-F® polymers as well as the other 3M Chemicals for the aircraft and missiles field: KEL-F® Molding Powders, Dispersions, Elastomers and Fluids, Fluorochemical inert fluids and other specialty chemicals.

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

... WHERE RESEARCH IS THE KEY TO TOMORROW



KEL-F® POLYMERS BY 3M exhibit no cold flow, can be extruded as shown above, injection or compression molded, or machined.

High dielectric strength: Short time 1/16"—530 v./mil. Very high volume resistivity: 1.2x1018 ohmcm. at 50% relative humidity and 25°C. Arc resistance > 360 sec. Chemical and dimensional stability: After 7 days immersion in white fuming nitric acid at 90°C, weight change was only 0.3%. Wide temperature range (-320°F to +390°F) without losing useful mechanical properties. In certain applications, KEL-F® has been used at point approaching absolute zero (-460°F).

INDEFINITELY

For free literature, write on your company letterhead, specifying prod-

uct interest, to 3M Chemical Division, Dept. WG-89. St. Paul 6. Minnesota.



3M CHEMICAL DIVISION, MANUFACTURERS OF: Acids • Resins • Elastomers • Plastics · Oils, Waxes and Greases · Dispersion Coatings . Functional Fluorochemicals • Inert Liquids and Surfactants.

INDICATOR prints digital data



The Model 176 digital indicator and printer permanently records weight, strain, temperature, pressure, and other variables measurable with sensitive bridge-type transducers, says Gilmore Industries, Inc., Dept. S/A, 13015 Woodland Ave., Cleveland 20, O. Printed tape recordings of the variable may be obtained at rates up to two readings per sec.

The device includes controls for run and calibration selection, with optional automatic readout-time-interval selection.

Write in No. 207 on Reader Service Card

COOLING UNITS are mobile



These Mobile Cooling Units are used to control temperature and to circulate hydraulic oils or electronic cooling fluids such as fluorochemicals. Capacity is 5,000 watts input (17,000 btu/hr) and ten gallons of oil per min, can be circulated against a maximum pressure at 250 psi. Units are available with either water cooled or a'r cooled heat exchangers, says Young Radiator Co., Dept. S/A, Racine, Wis.

The cooling unit is completely equipped and can be furnished with pumps having special Teflon seals for extremely low viscosity fluids.

Write in No. 208 on Reader Service Card

MIDGET SOLENOID is high-powered

This midget solenoid for continuous and intermittent duty combines maximum power capacity with small size for efficient performance in miniaturized assemblies. Plunger strokes adjustable from ½2" to ½6" with a maximum lift of 11 oz, continuous duty; 24 oz, intermittent duty, according to Guardian Electric Mfg. Co., Dept. S/A, 1621 W. Walnut St., Chicago 12, Ill. Overall dimensions: 34" high x 11/8" long x 3/4" wide.

Designated No. 22 D.C., coil values range from 6 to 110 v, dc only; shipping weight, about 2.5 oz.

Write in No. 209 on Reader Service Card

RIGHT-ANGLE ADAPTER has low VSWR



2000-UG-1264/U Type rightangle adapter is built to meet latest USAF specifications. The unit has a VSWR of 1.15 to 1 and an insertion loss of 0.1 db from 350 to 500 mc, Tamar Electronics, Inc., savs Dept. S/A, 2339 Cotner Ave., Los Angeles 64, Calif.

The adapter also features a captivated continuous center conductor covered with a continuous Teflon dielectric. The unit will handle up to 500 W and will meet Mil-E-5272. It weighs 7 oz and meaures 3¾ in. by 3 in.

Write in No. 210 on Reader Service Card

PRESSURE PROBE is water-cooled

A water-cooled total pressure probe, that can be provided with any number of measuring points, has an all-welded, stainless steel construction. Individual pressure measurements can be made at each point, says United Sensor & Control Corp., Dept. S/A, Box 127, Glastonbury, Conn. Cooling water is circulated through the tubes and either sprayed out into the air stream or returned to the water pump.

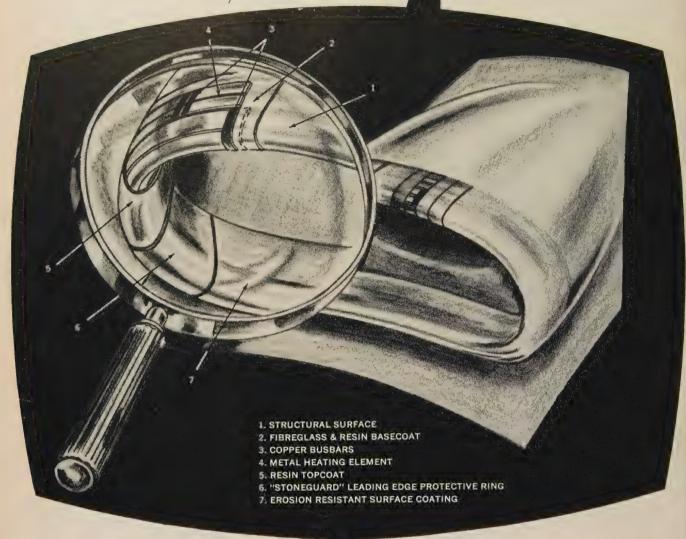
It can be used to take velocity measurements and thrust measurements in high velocity flames, such as in burners and in jet engine thrust

Write in No. 211 on Reader Service Card more on page 216

napier SPRAYMAT

anti-icing/de-icing...

OVER
15,000,000 MILES
OF SERVICE



After 9 years of development, testing and service, SPRAYMAT electrothermal ice elimination system has been enthusiastically accepted in the United States, and is in use on such aircraft as Lockheed's Electra and North American's Sabreliner, and was successfully tested on Lockheed's C-130A. SPRAYMAT has long been in use on such aircraft as the Britannia, Comet, Caravelle, Friendship, Vanguard, Viscount 810 and many others.

SPRAYMAT can be applied to *any* surface, of any material, however complex the curvature. Simple field repairability and aerodynamic and thermal efficiency assures its superiority to any existing system.

Basically, as shown in the above diagram, SPRAY-MAT consists of, first, a base of insulating resin; next a layer of metallic heater element of a controlled, predetermined design pattern; and finally a mirror-finish

coating of insulating resin. Under normal operating conditions, the service life of **SPRAYMAT** will exceed that of the aircraft structure itself!

Other applications for SPRAYMAT include: solid rocket propellent fusing radiant heat panels heated tools and molds de-fogging of camera lenses heating of components in unheated unpressurized areas heat blankets

PacAero is SPRAYMAT's sole United States manufacturer and distributor. A call or letter will bring you into immediate contact with a well-informed SPRAYMAT sales-engineer to discuss the application of SPRAYMAT to your specific ice-protection problems.

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you need this book



Every engineer whose problems involve the use of 400 cycle high frequency ac, and low voltage dc motors—or 400 cycle actuators, either rotary or linear, should have this book.

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Structures Engineers

The Columbus Division of North American Aviation. Inc. is seeking senior structures engineers for design, development and analysis on advanced projects, both aircraft and missiles.

Structural Analysts

Capable of computing internal load distributions and analyzing complex structures. Assignments include solution of redundant structures, loads distribution, structural testing or preliminary design support.

Airframe Designers

Will be assigned to an integrated structural group where the opportunity to calculate your own stresses along with responsibility for laying out airframe components is available.

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THE COLUMBUS DIVISION OF NORTH AMERICAN AVIATION, INC.

Home of the T2J Buckeye and the A3J Vigilante



BRAKE VALVE for airborne systems



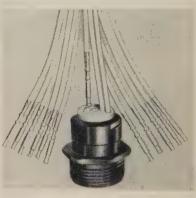
The MC 2655 brake valve is intended primarily for use with airborne air or nitrogen systems, says M. C. Mfg. Co., Dept. S/A, Lake Orion, Mich. The valve operates over -65 to +160-deg F and at pressures up to 3000 psi.

The 1.58-lb unit, designed to meet applicable portions of Mil-P-8564A (ASG), can also be used as a variable adjustment pressure reducer and in

ground service.

Write in No. 212 on Reader Service Card

PUSH-IN CONTACTS are automatically crimped

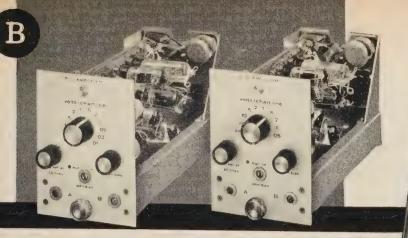


This push-in contact insert is designed for high-speed wire termination of high reliability; contacts are crimped automatically or semi-automatically to wires outside of the connector and space is allowed for working and inspecting the security of the crimp. A cross-hole in each contact permits ready inspection of the termination joint to determine the depth of the wire engagement, says Pyle-National Co., Dept. S/A, 1334 N. Kostner Ave., Chicago 51, Ill.

A special hand tool is used for inserting the contacts into the premounted resilient insulation within the connector barrel shell.

Write in No. 213 on Reader Service Card

more on page 218



Brush 6-8 channel recording system

RECTILINEAR . . . COMPACT PRECISE . . . SIMPLIFIED!

THE new Brush 6-8 channel recorders are designed to give highest reliability and preciseness to readouts for telemetry, computer, ground control and other data gathering systems—with a maximum of simplicity.

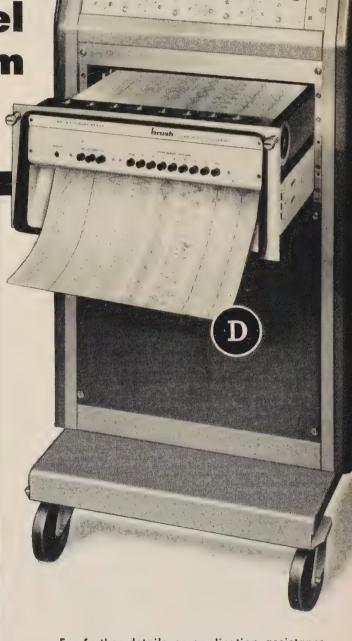
A Complete 6 or 8 channel system includes slide mounted oscillograph—signal conditioning amplifiers—requires only 20" of rack height.

B Interchangeable plug-in signal conditioners. In addition to amplification, four important functions are provided: high input impedance, zero suppression, attenuation and calibration.

C "Pull-out" horizontal writing table permits convenient annotation, reading and control—without removing chart paper or turning off recorder.

D Rectilinear presentation gives clear, uniform and reproducible traces for simplified analysis and interpretation. Excellent resolution at all amplitudes and recording speeds.





For further details or application assistance, contact your Brush factory branch or engineering representative.

brush

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EPUBLIC VAL



FREE-FLOW CHECK VALVES

No leakage. 3000 psi. Very low pressure drop. Can be furnished to open at 1/4 to 35 Brass, stainless steel, or aluminum alloy. ½" to 2" pipe or tube. Temp. range -65° to 200°F.

RELIEF VALVES

Quick unloading, smooth operation. Guided shut-off piston with stainless steel or Nylon seat. Pressure range to 4000 psi. Brass, aluminum alloy, or stainless steel. \(\frac{1}{3}'' \) to \(\frac{3}{4}'' \) pipe or tube. Temp. range to



HAND PUMP

For hydraulic applications on missile carrier and support equipment. Double-acting. 2 cu. in. displacement per cycle. 1000 psi. working pressure. Aluminum alloy body, stainless steel trim. -65° to 160°F.

LEVELATOR VALVE

For automatically maintaining height and level condition in any vehicle with air spring suspension. Controls swaying in transit, and off-level position while standing. Appli-cable to trucks, buses, trailers, carriers, cranes, etc.

LO-TORQ SELECTOR VALVES

Smooth, easy operation, with low turning torque because of pressure balancing design. 0 to 6000 psi. Bronze, steel, or aluminum alloy. ½" to 2" pipe or tube. 2, 3, 4 ports.



DUAL HAND PUMP

2 pumps, 2 relief valves, and 2 needle shut-off valves, compactly manifolded for elevating mechanisms, hydraulic applications on ground support equipment, etc. Aluminum alloy body, stainless steel trim. -65° to 160°F.

Distributors in principal cities coast to coast



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PLUG

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Write in No. 130 on Reader Service Card

SPRING WIRE operates to 1000° F

Superalloy spring wire made of Inconel X for aircraft, missiles, electronics, automotive and other high-temperature components that operate between 650° and 1000° F. is heat-treatable nickel-chromium, iron, titanium material that can be precipitation hardened. The wire is available annealed from 0.005 to 0.166-inch diameter, in spring temper from 0.005 to 0.180-inch diameter, and in No. 1 temper from 0.005 to 0.230-inch diameter, says National-Standard Co., Dept. S/A, Niles, Mich.

Spring temper is recommended for operating temperatures from 650 to 750° F. Corresponding tensiles range from 190,000 to 270,000 psi, depending on wire diameter.

Write in No. 214 on Reader Service Card

COUPLING quick disconnect

A quick-disconnect coupling, type 5-5012, for demanding hydraulic systems in aircraft and missiles, exceeds Mil-C-25426 with a rating of 4000 psi. It is for applications where the severe impulse requirements of Mil-C-25427 are not required and it may be used with operating pressures up to 6000 psi, says On Mark Couplings, Inc., Dept. S/A, 4440 York Blvd., Los Angeles 41, Calif.

A locking device, an integral part of the coupling, gives a full 360° grip on the mating part for maximum locking power. It will withstand extremely high pressure and shock loads, yet can be coupled or uncoupled without special tools with no spillage, it is said. It is available in sizes from 1/4" up.

Write in No. 215 on Reader Service Card

CONTROLLER for rocket thrust

This hydromechanical controller can sense and correct small errors in thrust chamber pressure in liquid propellant, rocket engines by producing a rate of change in actuator position. The actuator can be used to govern the flow of propellant to a gas generator or the flow of hot gas from the generator to the turbine, thereby, controlling turbine speed and propellent flow to the main rocket thrust chamber, says Bendix Products Div., Bendix Aviation Corp., Dept. S/A, South Bend, Indiana.

The controller has a two-stage pressure regulator for obtaining an accurate reference, a high gain pressure error sensing diaphragm, and a two-stage hydraulic amplifier. A pneumatic phase-lead device is incorporated in the controller for obtaining a damping signal proportional to the rate of change in thrust chamber pressure. A torque motor in the control permits changing the engine thrust level as a function of a remote electrical control signal.

Write in No. 216 on Reader Service Card

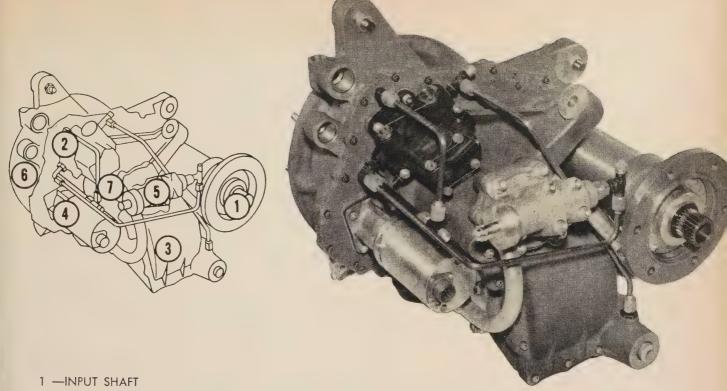
TRANSDUCER for severe conditions

This low pressure ruggedized Model L transducer is for use under severe environmental conditions and is said to be applicable for continuous use in vibrational environments of 20 g or more. Working fluids are completely isolated from electrical elements. Oil filled for elimination of internal resonances and extension of service life of the potentiometer, aneroids and other moving componets.

Said to be a unique feature by Servionic Instruments, Inc., Dept. S/A, 640 Terminal Way, Costa Messa, Calif., the case and fitting configuration permits stacked arrangements for compact mounting and ease of access to pressure and electrical fittings.

Write in No. 217 on Reader Service Card

more on page 222



Accepts varying input speeds from 3800-7000 RPM.

2 —GOVERNOR

Maintains $\pm 0.25\%$ steady state speed over 200° F temp. range, $\pm 0.5\%$ for 400° F temp. range and 0.5 second maximum full load transient recovery time.

3 -VARIABLE DISPLACEMENT PUMP/MOTOR

Either pump or motor, depending on whether it is adding to or subtracting from drive speed.

4 -- OVERSPEED GOVERNOR

Senses a predetermined excessive speed to prevent drive overspeeding.

5 -MAIN SYSTEM RELIEF VALVE

Overload protection for hydraulic system.

6 - DIFFERENTIAL GEAR SECTION

Ring, sun and planet gears. Also includes take-off gears for governors, scavenge and make-up pumps.

7 —FIXED DISPLACEMENT MOTOR/PUMP

Drives, or is driven by, sun gear to control output speed at 6000 rpm in response to fluid flow exchange with variable delivery unit.

A SIGNIFICANT ADVANCEMENT-

Differential Type Constant Speed Drive For Aircraft Alternators

cests now in progress on this 60 kva Vickers Differential Type Constant Speed Drive are proving its outstanding performance. See curves) It combines Vickers dependable hydraulic pumps and motors with planetary gearing to provide a more efficient and lighter "package" than drives now available.

he differential type constant speed drive is a direct engine-driven ransmission that can be either engine pad mounted or universal haft driven. It employs the "differential drive" principle wherein ne planetary gear train is the principal power vehicle and the ydraulic components differentially add or subtract speed and nower to maintain constant output speed. For further information, write for Bulletin A-5221.

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DIVISION OF SPERRY RAND CORPORATION

Aero Hydraulics Division

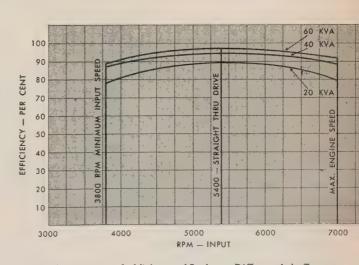
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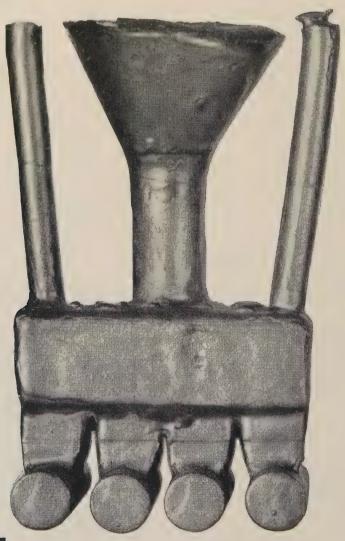
P.O. Box 2003 • Torrance, California



Performance of Vickers 60 kva Differential Type Constant Speed Drive at three different loads. The high efficiency requires minimum support equipment for cooling with minimum penalty for high temperature operation (400°F oil temp.)

Write in No. 131 on Reader Service Card at start of Product Preview Section

Cannon-Muskegon customers nothing ¶ Cannon-Muskegon research has developed certain procedures for investment casting of 17-4PH that assure, consistently, the high level of properties which this alloy is capable of producing. ¶ Casting test bars in a keel block arrangement as shown here—rather than an end-gated arrangement—is one of them. Special recommendations on aging time and temperature are another. ¶ Further, Cannon-Muskegon research has demonstrated the necessity of stricter limits to provide a balanced chemistry and prevent harmful effects induced by too high or too low a content of certain elements. Keeping within these limits and following Cannon-Muskegon recommendations assures investment casters of consistently obtaining optimum performance from this fine alloy. ¶ We invite you to write for a free copy of the ICI Technical Research Report, "The Effect of Aging Time and Temperature on the Mechanical Properties of Investment Cast 17-4PH."





CANNON-MUSKEGON CORPORATION

Metallurgical Specialists

2837 Lincoln Street

Muskegon, Michigan



167 Operations to Reliability

The machine operator in the foreground is chamfering a bore—the 37th operation on a Janitrol pneumatic control body. He works routinely to ±.0001" and has the mental flexibility to adapt to rapid design changes. He's been machining aircraft pneumatic parts for many years and has a deep respect for precision as an essential factor in reliability.

Janitrol people—whether designing heat exchangers, testing pneumatic controls, or fabricating high performance duct couplings—know that sudden design change is part of the means to reliability. They can handle it.

When your advanced missile and aircraft designs demand imaginative and knowledgeable sub-system management, and when you need a proposal for air supply systems, controls, heat exchangers, duct couplings and supports, or combustion systems for aircraft and ground support, call on your Janitrol Engineering Representative. Janitrol Aircraft Division, Surface Combustion Corporation, 4200 Surface Road, Columbus 4, Ohio.

pneumatic controls • duct couplings and supports • heat exchangers • combustion equipment for aircraft, missiles, ground support





Swivel Joints and assemblies to handle cryogenic liquids and fuels in ground loading and topping hose. Assemblies developed to handle services ranging from $-320^{\circ}\mathrm{F}$ to $+600^{\circ}\mathrm{F}$ and pressures from 20'' vacuum to 15,000 psi.

FOR GROUND SUPPORT EQUIPMENT

Loading arms and flexible transfer assemblies for handling Lox, N₂, He, JP Fuels, H₂O₂ and Hot Gases. Sizes range from ¼" to 16". Corrosion resistant steel, nickel, brass, aluminum, bronze and other metals available.

FOR GROUND HANDLING EQUIPMENT

Swivel Joints and assemblies to handle hydraulic, pneumatic, and fuel systems on launching vehicles and missile transporters. Units for rotation in 1, 2 or 3 planes in widest variety of metals, pressure and temperature available.



FOR AIRCRAFT SYSTEMS

Compact, lightweight package units in ¼", %", ½" and 5%" O.D. tubing sizes. Pressures of 28" vacuum to 4,000 psig. Temperatures of -65°F to +275°F. AN and MS standard end connections.

CHIKSAN COMPANY

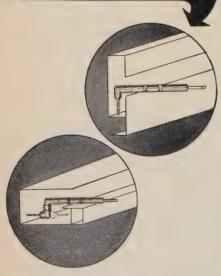
A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION CHIKSAN COMPANY—BREA, CALIFORNIA



Send for informative Bulletin 558

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PHASE MODULATOR for X-band

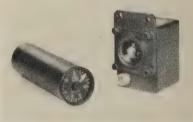


Model W-183-IE X-band ferrite phase modulator may be used as a frequency translator, a sideband generator, or an electronically controlled phase shifter. Amplitude modulation is less than 0.3 db variation with control current, and the unit has a frequency range of 9.75 to 10.75 kmc, with insertion loss of 0.5 db nominal, says Kearfott Company, Inc., Microwave Div., Dept. S/A, 14844 Oxnard St., Van Nuys, Calif.

A phase shift of 360 deg minimum and a typical VSWR of less than 1.10 are other features. Peak power is 5 KW; avg. power is 10 W. Typical control power for 360 deg modulation at 10 kc is less than 5 W. The unit weighs less than 1 lb and has insertion dimensions of 6 in, by 15% in. Phase modulators are also available for S- and C-band applications.

Write in No. 218 on Reader Service Card

MASS FLOWMETER is miniaturized



This miniaturized mass flowmeter system is said to offer higher accuracy in measuring fuel flow on reciprocating aircraft engines as well as small turboprop and small jet engines. It measures the mass of fuel passing into the engine rather than its volume. The small, lightweight system has two basic components, a type TJ-64 transmitter and a type DJ-99 remote indicator, giving continuous indication of the mass rate of fuel flow up to 1,200 lbs. per hour. Weight is under 4 lbs.

It operates on 115 volt, 400 cycle power and, according to General Electric Co., Dept S/A, Schenectady 5, N. Y., will withstand severe mechanical abuse such as vibration and a wide temperature range -65° F to + 300° F.

Write in No. 219 on Reader Service Card more on page 224

SPACE/AERONAUTICS



Bendix* has long been a leader in supplying controls and fuel systems for all types of aircraft engines. Today, Bendix is proving to be a natural for new challenges in related missile fields—on ram jets, rockets, nuclear power, and other advanced propulsion systems. So, when it comes to controls, remember that Bendix has the background—and is anxious to share it in solving your problems.

*REG. U.S. PAT. OFF.

BENDIX PRODUCTS SOUTH BEND, IND.



TEST STAND for air compressor



Th's compact air compressor test stand was designed to test 4-stage, 3000 psi auxiliary air compressors, ranging from 2 to 8 cfm. It is driven by 440 volt 60 cycle, 3 phase ac, and uses 208 volt, 400 cycle 3 phase power for special applications. The vibration-free stand has instruments which indicate every function, is equipped with numerous safety devices and break-ins or check-outs can be run unattended. A failure at the break-in end trips visual and audible alarms and shuts down automatically, says Walter Kidde & Co., Inc., Dept. S/A, Belleville, N. J.

A self-contained pneumatic system is automatic and supplies air up to 3000 psi for leak and functional

Write in No. 220 on Reader Service Card

CONNECTORS are stronger

This series SMI-C subminiature precision connectors have a unique stainless steel reinforcing retainer provided under each screwlocking element to remove all torque stresses from the molded bodies, avoiding breakage, says U.S. Components, Inc., Dept. S/A, 454 E. 148th St., New York 55, N.Y.

Positive re-entrance of the male pins is assured each time by a specially flanged guide female contact. Self-alignment action is assisted by wider countersink on upper end of contact. The connectors are available in total contacts of seven, 11, 14, 20,

Write in No. 221 on Reader Service Card

SOCKET CAP SCREWS speed up assembly

This flat head socket cap screw provides easy assembly and close fit together with "great" holding power. It is cold forged. The screw is said to have deeper sockets with the hex running to the bottom of the socket and free of chips, according to Brighton Screw & Mfg. Co., Dept. S/A, 1841 Reading Road, Cincinnati, O. Sides of the head come to a sharp,

even edge at the top with a uniform

Write in No. 222 on Reader Service Card

PRESS NUT floats within retainer



This floating press nut incorporates all of the advantages of the fixed press nut plus float of the nut within its retainer (.030 total). Installation calls for punching or drilling one hole and pressing the nut in place. Offers advantages of lighter weight, maximum resistance to push-out and torque-out, cheaper and faster installation and elimination of rivets normally required for float type fasteners, says Rosan Inc., Dept. S/A, 2901 W. Coast Highway, Newport Beach, Calif.

The nut is available in carbon steel in sizes no. 4 through 1/4".

Write in No. 223 on Reader Service Card more on page 226

NEW! BETTER THAN EVER ALL ANGI K INSPECTION MIRROR



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4 Heavily chrome-plated; precision-made.

ULLMAN DEVICES CORP.

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Can Tiny Bearings "Take It"?

MPB pivot bearings can. Smaller than 1/2" O.D., a single bearing can withstand severe shock, thrust and radial loads, and constant vibration - performs faultlessly with low frictional torque.

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MPB helps you perform miracles in miniaturization

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Write in No. 139 on Reader Service Card SPACE/AERONAUTICS

ULLMAN



TAPEnology provides new tool for preserving space age weapons

A remarkable new pressure-sensitive tape—"SCOTCH" Brand Plastic Tape No. 481—now makes positive preservation sealing of openings in idle aircraft, missiles and other vital standby equipment a reality. It sticks at a touch . . . provides all-weather protection almost indefinitely . . . yet removes

This new member of the "SCOTCH" Brand Tape family conforms to irregular surfaces easily . . . provides a good moisture-vapor barrier . . . is flexible over a temperature range from -60°F. to +160°F.... is inert to most common fuels, lubricants, oils, solvents . . . resists shrinkage even under extreme outdoor exposure. Special adhesive sticks to any clean, dry surface at below freezing temperatures . . . resists staining . . . removes cleanly without adhesive transfer.

What do you want preserved? Chances are, this new "SCOTCH" Brand Plastic Tape will offer you important advantages in protection, cost, and application utility. Ask your nearest "SCOTCH" Brand Tape Distributor for more information, or write: 3M Co., 900 Bush Ave., St. Paul 6, Minn., Dept. IAO-89.

When tape costs so little, why take less than "SCOTCH" Brand?

SCOTCH SCOTCH SCOTCH

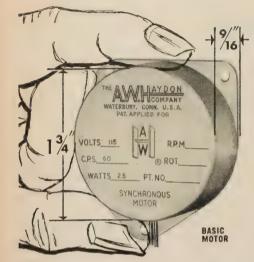
"SCOTCH" is a registered trademark for the pressure-sensitive adhesive tapes of 3M Co., St. Paul 6, Minn. Export: 99 Park Ave., New York 16. Canada: London, Ontario

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ANOTHER FIRST...



% A.C. TIMING **MOTOR**

Thinner... Ouieter . . . More Reliable . . . More Versatile

FINGER-THIN . . .

Only 9/16 Inches Short . . . Only 13/4 Inches in Diameter . . . very compact ... reduces the size of your equipment.

WHISPER-QUIET . . .

Strictly an electrical motor . . . practically noiseless . . . no rattling of gears or ratchets.

HIGH TORQUE . . .

1/4 oz. inch at the rotor with instantaneous start and stop . . . requires only 2½ watts . . . can replace larger motors in recorders, controls and telemetering equipment.

HIGHEST RELIABILITY ...

Longer life . . . no one-way gears or ratchets to fail . . . provides millions of operations without any trouble.

SPECIFICATIONS

Standard Voltage Ratings: 6, 12, 24, 115, 230 Volts Frequency: 60 CPS Standard 25, 50 CPS Available Power Input: 2.5 Watts Maximum (60 CPS)

BASIC MOTOR Weight: 4 ounces Speed: 300 RPM Torque: ¼ oz-in. Length: 9/16 inch

WITH INTEGRAL GEAR TRAIN Weight: 5 ounces Sneed: 300 RPM to 1/6 RPH Torque: 30 oz.-in, @ 1 RPM Length: % inch



WITH INTEGRAL GEAR TRAIN

@ 1959



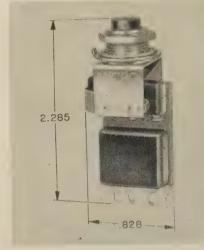
Send For Special Illustrated Bulletin AWH MO-806

HAYDON Company 223 NORTH ELM STREET, WATERBURY 20, CONNECTICUT

Custom Design & Manufacture Of Electronic And Electro-Mechanical Timing Devices

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ONE-SHOT SWITCHES for high speed operation



The IPB600 series of pushbutton switch assemblies, which have an electronic circuit to produce a single, microsecond-length pulse with each operation, eliminates the need for designing special pulse input circuits for high speed electronic switching devices, says Minneapolis-Honeywell Regulator Co., Micro Switch Div., Dept. S/A, Freeport, Ill.

The square-wave pulse width is are independent of the speed of switch operation. The circuit used in the switches includes a capacitor, a resistor, a magnetic core, and diode. All components are potted in a modular package. Temperature range is -65 to +185 deg F.

Write in No. 224 on Reader Service Card

FUEL COUPLER operates at 1000 psig

This remote actuated quick disconnect coupler built for gaseous oxygen, gaseous nitrogen and RP-1 rocket fuel applications is constructed from 17-7PH and 300 series stainless steel, and has a working pressure of zero to 1000 psig. Proof pressure is 2000 psig and burst pressure is 3-000 psig. Furnished in line sizes ¼, %, ½, 5%, ¾, 1, 1¼, and 1½ in., this new special design quick disconnect unit has a pressure drop in all sizes at absolute minimum, says Bruning Co., Dept. SA, Lincoln, Nebraska.

Leakage at zero to 1000 psi, both connected and disconnected, is zero. Disconnecting can be achieved by manual pneumatic or lanyard methods. Under line load of 1000 psi, pneumatic disconnect is implemented with 200 or 750 psig; while lanyard disconnect takes 50 lb max pull. The disconnect unit is said to surpass MIL-E-5272 for vibration.

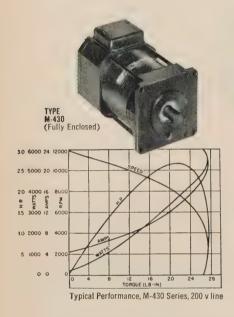
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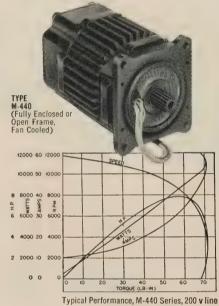


VISIT US AT BOOTH NO. 847—ISA SHOW—CHICAGO licensee and manufacturer for Great Britain, British Co Write in No. 142 on Reader Service Card at start of Product Preview Section

new high-performance motors from AIRBORNE

M-430, 440 Series typify capabilities in meeting special design requirements These 400-cycle, 3-phase, 115/200 v a-c motors were developed originally as components of Airborne large special actuators for aircraft/missile applications. Because of their useful performance characteristics, we now offer them separately—both as additions to our line of special motors and as examples of Airborne capabilities in their particular class of application.





M-430 Series, 3-in. frame

Intermittent duty ratings to 1.8 hp; continuous ratings to 1.0 hp. Available with magnetic brake which will stop motors in 22 rev. from no-load speed and provide 30 in.-lb. holding torque. Model shown is a 7.5 lb. brake-equipped motor rated 1.5 hp at 10,000 rpm under a duty cycle of 0.5 min. on, 9 min. off.

M-440 Series, 4-in. frame

Intermittent duty ratings to 5 hp; continuous ratings to 2.5 hp (neither of these are absolute ceilings). Optional brake provides holding torque of 140 in.-lb., stops motors in 20-40 rev. from no-load speed. Model shown weighs 13.2 lb. with brake, is rated 4.0 hp at 10,000 rpm—1 min. on, 1 min. off.

Whatever your requirements in large special high-performance motors—a-c or d-c—it will pay you to check with Airborne. Most likely we can furnish a motor of minimum weight and bulk that will meet exactly your specifications. Write or phone any of our offices.

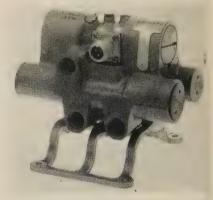


Engineered Equipment for Aircraft and Industry

AIRBORNE ACCESSORIES CORPORATION

HILLSIDE 5, NEW JERSEY • Offices in Los Angeles and Dallas
Write in No. 143 on Reader Service Card at start of Product Preview Section

SELECTOR VALVE is compact, versatile



This 6-way, 4-position solenoid operated selector valve combines the functions of two separate valves which control the landing gear and doors in a 3000 psi 275° F aircraft hydraulic system. The unit achieves additional porting and positions over 4-way valves with two solenoid pilot valves, according to Hydra Power Corp., Dept. S/A, Pine Court, New Rochelle, N. Y.

The combining of 2 valves into one package eliminates 2 solenoids and 2 hydraulic line connections.

Write in No. 226 on Reader Service Card

JET STARTER weighs under 50 lb



This 3-way combination cartridge and air starter for jet engines permits choice of solid propellent firing, cross air bleed from another engine, or ground cart compressed air as the initial power source, and has been demonstrated successfully in the field on the J57-P59 engine. It is said to have two features: a centrifugal compressor integrated with the turbine wheel and automatic limiting of turbine speed without valves, switches, or servo mechanisms; a pressure limiting valve that gives positive safety during cartridge firing. It also controls breech pressure to minimize variations in performance at extreme temperatures, says Sundstrand Aviation, Dept. S/A, Rockford, Ill.

Starter requires only a conventional spur gear train eliminating all planetary gear arrangements.

Write in No. 227 on Reader Service Card

DIFFERENTIAL SWITCHES use air pressure



This differential air pressure switch with inches of water sensitivity for airborne applications is typically used for monitoring air speed, in which case the ports are connected to sense "pitot" and "static" pressures. The reference of "static" port can be screened for ambient pressure sensing. Two units, type 6580 and type 6557, provide snap-action switch operation to open one circuit and close another at a pre-set value of differential pressure within the range of 2½ to 135 inches of water. Minimum switch differential values fall within a range of 3¼ to 3 inches of water, says Consolidated Controls Corp., Dept. S/A, Bethel, Conn.

For type 6580, with one SPDT

For type 6580, with one SPDT switch element, one adjustment changes the switch actuation point and another changes the magnitude of the switch differential value. For type 6557, with two SPDT switch elements, the adjustments control the actuating point of each switch element separately.

Write in No. 228 on Reader Service Card

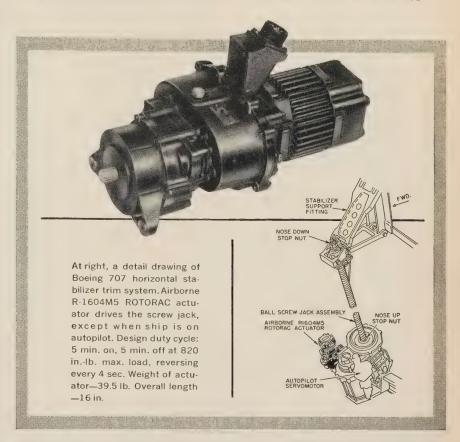
MINIATURE CONTACTOR switches up to 60 amperes

This miniature contactor is capable of switching loads up to 60 amperes with control signals as small as 2.7 W. Called the MB, it can be furnished with spst double break contacts either normally open or normally closed. In addition to normal load currents of 60 amperes at 30 V dc, it can handle starting surges up to 150 amperes for 300 ms. A double throw relay can also be furnished with contacts derated to 20 amperes, says Potter & Brumfield, Inc., Dept. S/A, Princeton, Ind.

The minuscule contactor can be furnished to operate under shocks of 30g and 10g vibrations to 500 cycles. The open version of the unit measures $1^{21}/_{32}$ in. long x $^{27}/_{32}$ in. wide x $1^{17}/_{32}$ in. high and weighs only two ounces. The hermetically sealed version measures 1% in. long x $17/_{16}$ in. wide x $7^{1}/_{8}$ in. high and weighs four ounces.

Write in No. 229 on Reader Service Card more on next page

POWERS 707 TRIM SYSTEM



Because of its function—operation of a primary flight control on Boeing's 707 — this Airborne ROTORAC large special actuator must provide the utmost reliability under almost continuous off-on-reverse type operation. And its response must be quick, even though maximum torque and acceleration are limited by specification — to avoid inadvertent structural overloads.

To control torque, Airborne developed a special friction clutch which limits output to 1500 in.-lb. maximum and yet will transmit 1200 in.-lb. under any condition. Controlled accelerations were achieved by balancing the inertia characteristics of all rotating parts

and of the external load against the carefully tailored performances of the motor and servo clutches. Result: smooth acceleration from 0 to 180 rpm in 0.4 second and shock-free reversal in 0.1 second, both at full load.

Airborne offers you engineering of this caliber to meet needs for almost any special rotary or linear electromechanical actuator—large or small. And where requirements are not unique, we provide a line of modular-type actuators, developed by Airborne to simplify design and specification. Just give us the facts on your application and we will be happy to make a proposal. Contact any of our offices for further information.

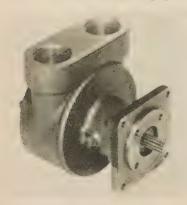


Engineered Equipment for Aircraft and Industry

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GROUND PUMP with mounting pad



This Tuthill model CBGFK pump is designed to meet Air Force-Navy Acronautical standards for use on ground equipment. The unit has a splined shaft, mounting pad, and port to meet AN-D specifications. Available in two sizes, with capacities from 10 to 45 gpm at 150 psi and for speeds to 3600 rpm. They can be adapted to a wide variety of applications, says Tuthill Pump Co., Dept. S/A, 939 E. 95 St., Chicago, Ill.

Other selections are pumps with capacities from $\frac{1}{3}$ to 200 gpm; for pressures to 1500 psi; speeds to 3600 rpm

rpm. Write in No. 230 on Reader Service Card

READOUT LAMPS equipped with resistors

Current-limiting resistors may now be obtained with the miniature replaceable-lamp indicators in the 1DH E-lite Series, says Eldema Corp., Dept, S/A, El Monte, Calif. The indicators are used in computers, dataprocessing machines, automated control systems, instrument panels, and other equipment.

The IDH replaceable-lamp holders are available with or without resistors, and with either neon or incandescent lamps. Lenses, in any of several colors, may be plain or flutd, round or flat, wide or narrow. The flat lenses, for data readout, accommodate up to three digits.

Write in No. 233 on Reader Service Card

PRESSURE VALVE for turbines

A high pressure, high speed, pressure scanning valve, designed for measuring turbo-engine pressures makes one ½ inch diameter flush diaphragm transducer scan 48 pressures in one second, according to General Design, Dept. S/A, 631 30th St., San Diego 2, Calif. Various motor speeds are available.

The valve is 2" in diameter x 6.5"

long. Write in No. 231 on Reader Service Card

RELAY has adjustable contacts

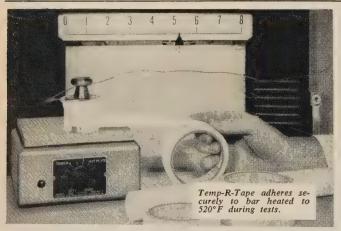


This non-indicating meter-relay, model 137 VHS, has adjustable contacts for changing control points or calibration. It offers the advantages of a standard locking coil meter relay except dial indication, is more resistant to shock and vibration, and is said to be smaller and more sensitive by Assembly Products, Inc., Dept. S/A, Chesterland, Ohio. The clear plastic case is 2" long x 13%" square. Length, including the 9-pin plug-in base is 2½".

The very high sensitivity triggers control action on signal changes as small as 0.2 micraampere, or 0.1 millivolt dc.

Write in No. 232 on Reader Service Card

more on page 232



CHR PRESSURE-SENSITIVE TEFLON® TAPES

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 - Class H and Class C insulation
 - · Non-stick and low friction facing
 - Chemical resistant facing
 - Easy to apply

Temp-R-Tape is available from stock in rolls and sheets. All four types — Temp-R-Tape T; TH; C and TGV — combine some form of Tefion backing with silicone polymer adhesive to provide easy-to-apply pressure-sensitive and thermal curing pressure-sensitive tapes for electrical and mechanical applications. Designed for extreme temperatures, Temp-R-Tapes possess high dielectric strength, low power factor, high elongation, negligible moisture absorption, are non-corrosive and non-contaminating.

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APPEARANCE? ASSEMBLED COST? PERFORMANCE? If assembled cost is your major fastener problem...



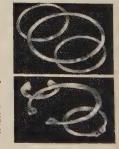
Ramco Spirolox-Circolox Retaining Rings can give you the ONE BEST ANSWER! Whatever it takes...rings designed from standard or special materials... designs for quick, easy assembly or with special tolerances... you can depend on Ramco. Why not write today for the new fact-packed Ramco Spirolox-Circolox Retaining Ring Engineering Information Catalog!



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The answer to easy, lightweight, low cost assemblies and reduced manufacturing costs. Made in a variety of types, sizes for smaller shaft or housing diameters.

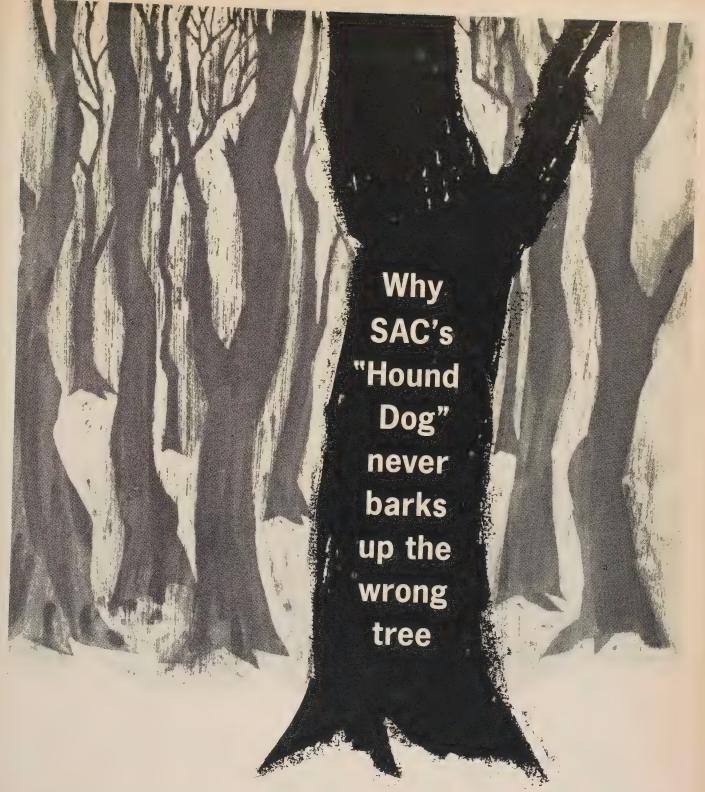


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SPACE/AERONAUTICS



Once unleashed from the B-52G, SAC's GAM-77 Hound Dog finds its target every time. Leaping ahead at supersonic speeds, the jet-powered missile can clear a path for its bomber by blasting ground defenses hundreds of miles away... or destroy the primary target itself.

Secret of Hound Dog's hunting instinct is its inertial autonavigator—designed and built by Autonetics. Set before missile launch by the crew of the Boeing B-52, the self-contained system can't be jammed ... can't be decoyed ... sees *only* the pinpoint coordinates of its destination.

Missile Guidance by Autonetics



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for the Space-Age

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T-Bolt Clamp—Series 10T

Same as 10QL but without patented quick-latch, and recommended for more permanent applications, Meets MS requirements governing Part MS21920.

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Complete range of sizes



Type AN737-TW (with shoe)



Type AN737-TWLS (without shoe)



Type AN737-RM (floating bridge)

CLAMPS

for Every

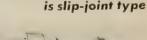
Descriptive literature or recommendations for any clamping requirements upon request.

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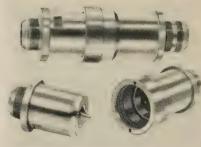
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4368 West 24th Place, Chicago 23, Illinois

Write in No. 148 on Reader Service Card at start of Product Preview Section



DISCONNECT COUPLER



This heavy duty liquid oxygen and liquid nitrogen disconnect coupler is a slip joint type that disconnects with a negligible breakaway force. It is made of 300 series stainless steel and chrome plated in wear areas. Operating pressure is from zero to 500 psi; with proof pressure of 1000 psi. Leakage at zero to 160 psi, both connected and disconnected, is zero, says Bruning Co., Dept. S/A, Lincoln, Nebraska.

Operating temperature range is -325 to +500 deg F. The coupler comes in tube sizes ½, ¾, 1 and 1½ in.

Write in No. 234 on Reader Service Card

GENERATOR SET is highly precise

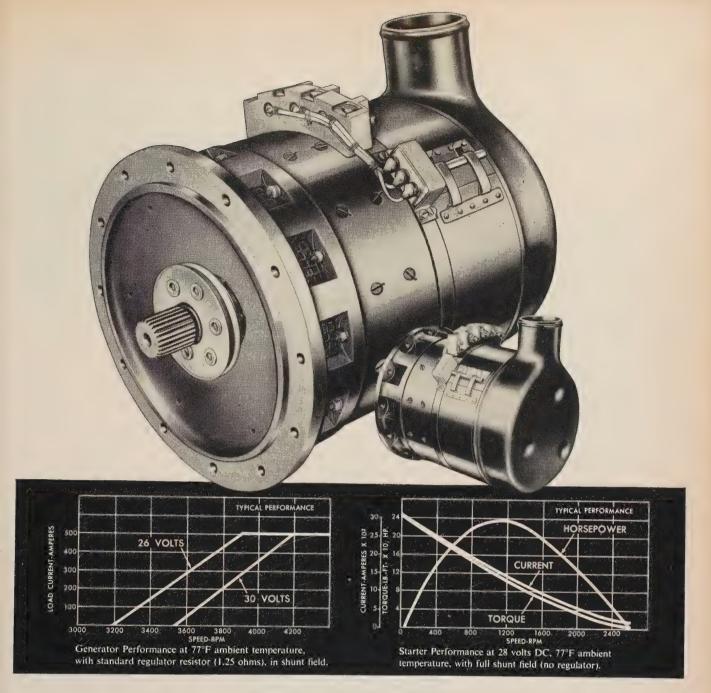


This lightweight, Precise Power generator set, said to meet the most exacting tolerance regulation standards of the armed forces, is a 100 kw, 3-phase 50/60 cycle, 208-240/-416-480 volt unit operating at 1500 and 1800 rpm. Driven by a 6-cyl. series 71 GM diesel, the unit weighs 5800 pounds, or up to 4400 pounds lighter than other comparable units, says General Motors Corp., Detroit Diesel Engine Div., Dept. S/A, Detroit 28, Mich.

Low transient reactance of .14 which cuts starting voltage dips to a minimum and a low negative sequence impedence of .11 provide the "ultimate in voltage balance." It was developed in conjunction with the Engineers Corps, Fort Belvoir, Va.

Write in No. 235 on Reader Service Card

more on page 234



One head is better than two ...

When you can combine the engine-starting and electric-powergenerating functions into a single machine it means one less mounting pad, less congestion, less space and less weight per installation.

Above are two views of the famous J&H G-32 starter-generator. More than 25,000 are in service today...running as many as 1000 hours without overhaul.

This G-32 design has sired the most complete line of startergenerators available from any manufacturer. Machines are rated from under 100 amps thru 750-amps d-c, and they will start engines up to 4000-lb thrust, or equivalent hp. They are particularly suited for aircraft and helicopters driven by turbojet and turboprop engines.

Control systems for the machines range from simple manual to completely automatic where operation, including "fuel-on" and "ignition-on" is reduced to one push of a button.

For free Starter-Generator Systems Data Book which describes the design and performance of the J&H machines and control systems and also their applications, write to: Jack & Heintz, Inc., 17634 Broadway, Cleveland 1, Ohio.

JACK & HEINTZ, Inc.

SYSTEMS FOR AIRCRAFT, MISSILES AND GROUND SUPPORT

Write in No. 149 on Reader Service Card at start of Product Preview Section

SERVOMOTOR is velocity-damped

A new Size 8 velocity-damped servomotor can replace motor-generator rate feedback for damping in many miniature systems, says Helipot Div., Beckman Instruments, Inc., Dept. S/A, Fullerton, Calif. Besides the same transfer function as a motorgenerator, Model 8 VM 420 offers lighter weight, smaller size, and lower cost.

In addition, it lowers power consumption and eliminates problems

normally associated with residual null voltage. The servomotor design permits use of an undersized rotor with a 0.24-gm cm² inertia. This, plus a stall torque of 0.25 oz in., produces an acceleration at stall of 73,000 rad/sec². No load speed of the 1.395-in. long unit is 5000 rpm, and the power input is 2.6 W. The 8 VM 420 has a 26-V fixed phase and 40-V center-tapped control phase; these windings can be modified to 60 V maximum.

Write in No. 236 on Reader Service Card

SOLAR CELLS are efficient



Up to eight per cent of the radiant energy falling on their surface can be converted into electrical power by silicon solar modules available from International Rectifier Corp., Dept. S/A, 1521 E. Grand Ave., El Segundo, Calif. Standard types will supply 100 W of power for each 14 sq ft of cell area. Converters with greater efficiency may be obtained for satellite and other special applications.

Modules can be interconnected in series-parallel configurations for any desired power rating. Each module contains five-series-connected solar cells, measuring 1x2 cm, in a rugged, shockproof epoxy housing.

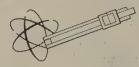
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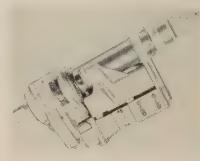
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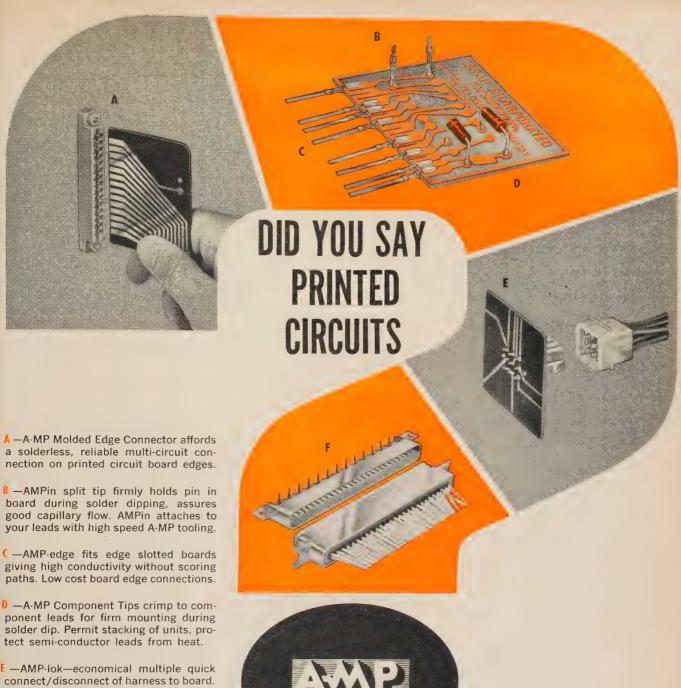
POWER ACTUATOR for horizontal stabilizer



This linear power actuator to control and position a horizontal stabilizer operates from input signals from the autopilot, has a normal load of 7,500 lbs, a maximum operating load of 15,500 lbs, and a proof load of 28,000 lbs, travel rate of 0.140" a second, a stroke of 2.500", according to Hoover Electric Co., Dept. S/A, Port Columbus Airport, Columbus 18, Ohio.

The unit weighs 18 lbs, has an adjustable position transmitter to operate with autopilot in a closed loop circuit. It has been qualified to Mil-A-8064 and Mil-E-5272.

Write in No. 238 on Reader Service Card more on page 236



F -A-MP Printed Circuit Connector, for gruelling aircraft environments, is sealed against moisture and arcing, attaches with right angle pins to circuit board edge. Dual leads for each contact.

> No matter how you approach printed circuit problems-with single or multiple connector units, with board-edge or face attachments, with or without solder dipping, with or without eyeletting-AMP has just the product you'll need for low-cost top reliability.

> Production and assembly speeds are miles ahead of most other techniques. Versatility is unbeatable, permitting A-MP products to be used on different applications and in combination with each other.

> For complete information on electrical characteristics, application methods and other specifications, send for our new Printed Circuit Applications Catalog.

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235 August 1959



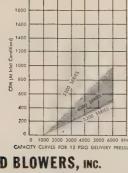
HELICAL GEARS

Every M-D blower shipped has a matched pair of crownshaved, lapped helical gears. Backlash tolerance is .0005" to .0015". No other blower matches M-D quality.

WHY M-D ROTARY POSITIVE BLOWERS develop higher pressures!

The unique combination of precision manufacture and modern design found only in M-D rotary positive blowers permits higher speed operation and higher pressures. For this reason M-D can furnish greater air flow at lower initial cost,

M-D blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 22 production models range from 50 to 4,000 CFM, pressures to 14 PSIG single, 70 PSIG multi-stage.





Write in No. 152 on Reader Service Card

236

ELECTRONIC TESTER locates bearing faults



This Electronic Bearing Analyzer, BA-22, detects and pinpoints hidden faults one-millionth of an inch without bearing dis-assembly. Bearings may be tested with or without grease, oil, or seals, and new bearings need not be cleaned before testing. Oscilloscope display and audible signal dial settings make possible reliable operation of the instrument by untrained personnel, says Bearing Inspection, Inc., Dept. S/A, 3311 E. Gage Ave., Huntington Park, Calif.

Radial or thrust type bearings may be tested under load conditions in either the vertical or horizontal plane, Ball and roller bearings up to 14" in diameter are checked with unusual accuracy.

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FIXED-LOOP ANTENNA for ADF systems

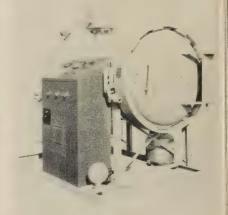


This unit comprises two basic elements: the LPA-71 fixed-loop antenna and the GMA-71 (A or B) goniometer and will improve the performance of all Arinc-approved ADF systems, says Bendix Aviation Corp., Bendix Radio Div., Dept. S/A, Baltimore 4, Md.

The antenna itself is less than 1 in. thick, enabling it to be mounted outside the skin of the aircraft—without the need for fairings or cavities. The only opening required is a hole large enough for the connector and an adapter will permit flush mounting in any existing Arinctype flush-loop cavity. Both versions of the goniometer are in standard S-in. cases. The antenna and goniometer weigh 2.9 lb. and 1.9 lb., respectively.

Write in No. 240 on Reader Service Card

EXPLOSION CHAMBER with fuel measuring



This explosion test chamber with a simplified fuel measuring system is designed to perform tests required under Mil-E5272A and Mil-E-005272B, for components or products which must operate in an explosive atmosphere, and for testing explosion-proof enclosures. It meets ASME pressure vessel code requirements. Altitudes up to 85,000 feet can be simulated for use with or without explosion tests, says Missimers, Inc., Dept. S/A, 3206 Los Feliz Blvd., Los Angeles 39, Calif.

Safety measures include a quickacting chamber door to seal the explosive force and which controls an interlock switch to insure full closure before the firing circuit can be energized.

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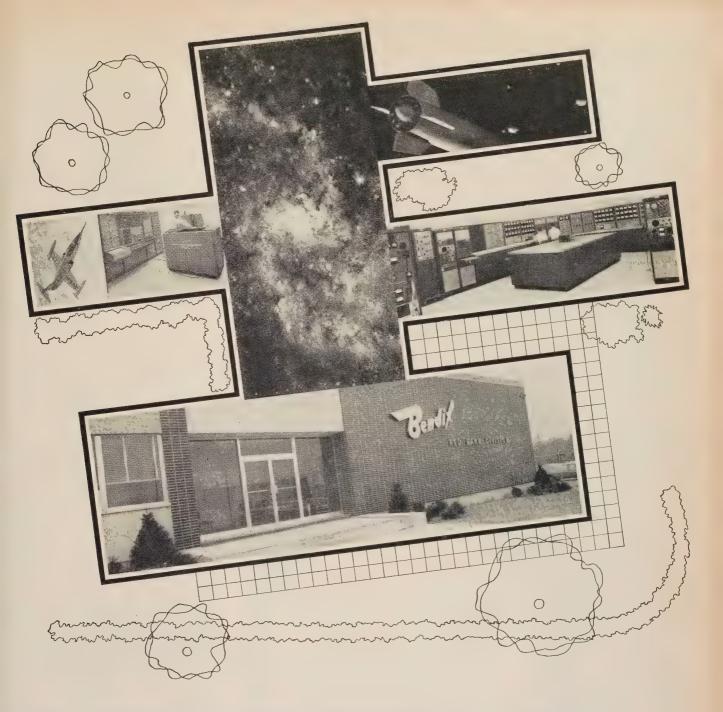
HOLDING VALVE hydraulic circuits

A holding valve, engineered to solve special problems in hydraulic circuits, has been developed which performs these basic functions: Locks a cylinder or motor when no motion is desired; prevents the load from running ahead of the oil supply when the load is being moved; relieves excessive pressures generated in the cylinder by load and, in case of power failure, it permits the load to be lowered manually. The advantages of the valve over counterbalance type are said to be little or no use of power when a load is being elevated and a nominal amount when it is being lowered, according to Sarasota Precision Products, Dept. S/A, 1312 N. Lime Ave., Sarasota,

The valve is designed to lock the cylinder and open with a pilot pressure assist of approximately 20% of the difference between the load induced pressure and the valve setting.

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more on page 238



THE HOUSE WHERE TOMORROW LIVES ...

Our newest engineering facility, in Eatontown, New Jersey, is dedicated to creating new ideas and products that will help you meet tomorrow's electronic, missile and aircraft needs today.

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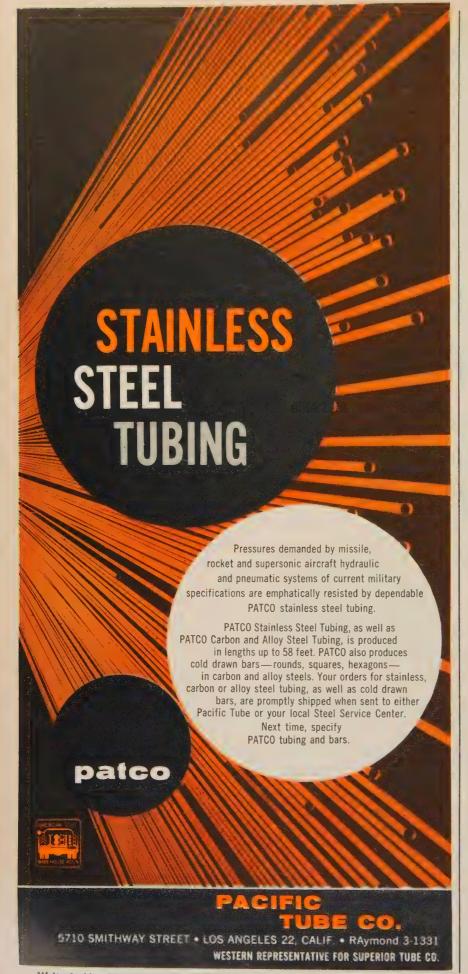
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Canadian Affiliate: Aviation Electric, Ltd., P. O. Box 6102, Montreal, Quebec.

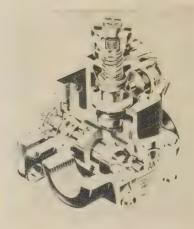


EATONTOWN, NEW JERSEY





FUEL PUMPS are highly versatile



These G-6 and G-9 rotary-vane, positive displacement fuel pumps are engineered for any engine design, for most fuels, and a variety of mounting and drive conditions. Weight, 2.8 lbs. They are available with a variable pressure relief valve for pumping fuel to the engine at uniform pressure. Rated capacities at 2500 rpm are 220 or 425 gph. Shaft operation is in either direction of rotation, says Titan Pump & Engineering Corp., Dept. S/A, Novi, Mich.

Pump consists of a main housing containing a carbon liner with an eccentric bore.

Write in No. 243 on Reader Service Card

SWITCH features overtravel



This switch features .100 over-travel and 1½ hp rating for appliance and automatic device applications. The case has environment-resistant interlocking design and standard mounting dimensions. Designated E18-OOA, it is said to be "ideal" for both new and replacement use and offers long life cycle and accurate repeatability, according to Cherry Electrical Products Corp., Dept. S/A, 1650 Deerfield Rd., Highland Park, Ill.

The wear-resistant nylon button provides smooth operation with or without actuators. A complete line of actuators includes roller leaf, leaf, push button and overtravel push button. Ratings are: 15 amps, 125/250v ac; 34hp, 125v ac; and 1½hp, 250v ac.

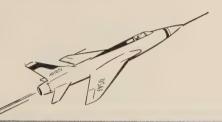
Write in No. 244 on Reader Service Card more on page 242

vital electronic equipment is "soft mounted" on F-105

Critical electronic units on the Air Force's Mach 2 F-105 Thunderchief fighter-bomber are "soft mounted" on LORD vibration control systems. Operational reliability is thus assured for a toss bomb computer, sight amplifier and two integrated electronics chassis.

Use of resilient suspension systems—custom designed—provides positive protection against the extreme disturbances of the advanced jet environment. By working with LORD, F-105 contractors obtained the lightest, most economical suspensions in the shortest time.

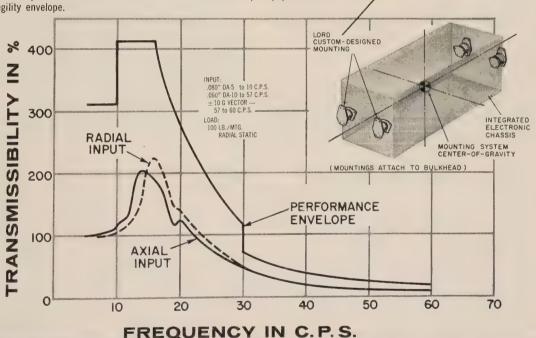
If you have a problem in the protection of sensitive equipment, LORD offers you a broad background of vibration/shock/noise control experience in air, space, marine and ground environments. Your inquiry will be welcomed. Contact your nearest LORD Field Office or the Home Office, Erie, Pa.



Vibration/shock/noise control—Two integrated electronics chassis on Republic F-105 jet fighter are mounted on special Lord high-performance isolators. Severe environment includes vibration, superimposed sustained accelerations to 9 G and 30 G shock loads throughout temperature range from -65° to $+200^{\circ}$ F.

In final design shown, four isolators weighing less than 1.5 pounds each support chassis weighing between 266 and 400 pounds. Use of Lord BTR (Broad Temperature Range) elastomer assures excellent damping plus constant performance over wide temperature range.

Transmissibility curve shows how efficient vibration isolation keeps equipment well inside fragility envelope.

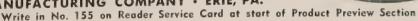


FIELD ENGINEERING OFFICES

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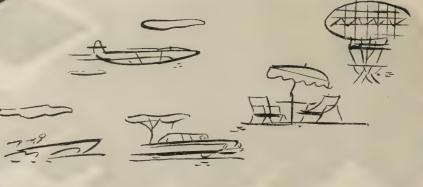
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Give you 5 additional benefits for Corrosion Protection—Paint Base—Decorative Finishing

A COMPLETE PROCESS

Developed for specific applications, there is an Iridite to provide the finish you desire, fit the equipment you have available and give the performance you require. Most Iridite coatings meet rigid military and civilian specifications.

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Our large field engineering staff is thoroughly familiar with chromate conversion coatings and related finishing operations. They'll help you check every step in your finishing operation to make sure you're getting the best possible finish on your products.

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Warehouses located in strategic industrial

areas enable us to provide you with fast, economical delivery on any Iridite.

4 ECONOMY

The superior performance of Iridite provides low final cost by extending operating life and lowering maintenance costs. In addition, Iridite gives you a finish that adds considerably to the value of your product. There's an Iridite to meet every cost and performance requirement.

RESEARCH AND DEVELOPMENT FACILITIES

If you have an unusual application, we will gladly work with you. Our entire staff of experienced engineers and chemists, and our completely equipped facilities are at your service.

IRIDITE—a specialized line of chromate conversion coatings for non-ferrous metals. Apply by dip, brush or spray methods — at room temperature — manually or with automatic equipment. Forms a thin film which becomes an integral part of the metal. Cannot chip, flake or peel. No special equipment, exhaust systems or specially trained personnel required.

If you are using chromate conversion coatings to finish zinc, cadmium, aluminum, magnesium, silver, copper, brass or bronze — consider the above benefits of Iridite. For complete information, contact your Allied Field Engineer. He's listed under "Plating Supplies" in the yellow pages. Or, write for FREE TECHNICAL DATA FILE.



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Chemical and Electrochemical Processes, Anodes, Rectifiers Equipment, and Supplies for Metal Finishing



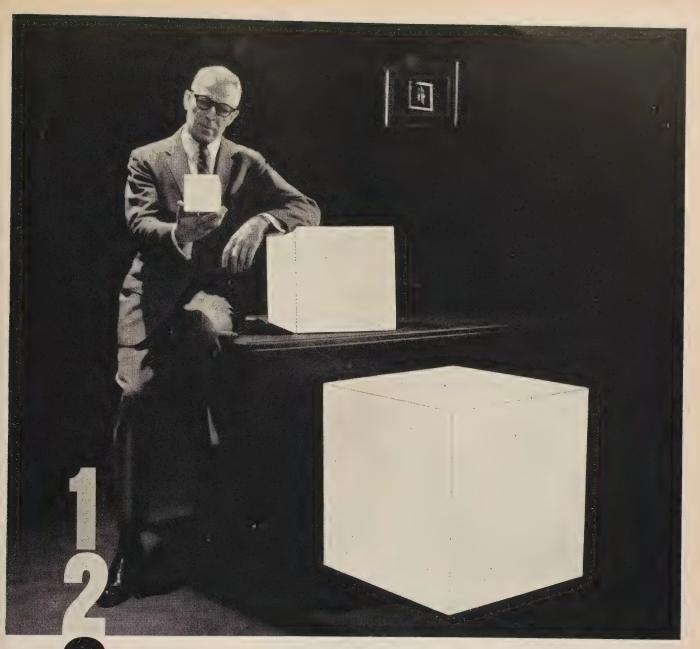








Write in No. 156 on Reader Service Card at start of Product Preview Section



generations of airborne digital computers (but we can't show you)

In the photo above, the three ARMA computers have been intentionally deleted. But the cut-outs accurately represent the relative size of the three generations of ARMA airborne digital computers.

The larger size has been *in production* since 1957. The middle-sized one (a quarter the size of today's) will be in production in 1960. And the micro-miniaturized version in the engineer's hand will be operational in 1962—only .3 cubic feet in volume.

A production line unit of ARMA's current model has operated in excess of 4000 hours without a component replacement. And the 1960 and 1962 versions will have reliability factors at least equal to this.

With this program of miniaturization, ARMA has made the digital computer truly airborne. ARMA...Garden City, New York. A division of American Bosch Arma Corporation.

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DYNAMICS ENGINEERS

Immediate openings for vibration, flutter, and dynamic analysis engineers to work on the most advanced weapon systems—such as the B-70, the F-108, and the X-15, first manned space ship.

A background in AE, ME, or other applicable experience is necessary. Qualified vibration engineers will calculate and measure vibration levels for consulting on procedures to insure crew comfort and work out vibration environment problems on equipment of particular airframes. The flutter and dynamic analysis engineers will evaluate flutter characteristics, including servo systems, of particular airframes by analytical techniques and by the use of dynamic models, and conduct other studies relating to gust penetration, landing, and taxi conditions.

For more information please write to: Mr. P.H. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

THE LOS ANGELES DIVISION OF

NORTH
AMERICAN
AVIATION, INC.

PNEUMATIC VALVES are "smallest", "fastest"



Two 3000-psi pneumatic solenoid valves, one the smallest and the other the fastest ever made, have been developed for missile systems, according to Walter Kidde & Co., Inc., Dept. S/A, 675 Main St., Belleville 9, N.J. They are also useful in some manned aircraft applications.

Valve 872071, the "smallest", has a zero-to-3000-psi range and operates over —75 to +350 deg F. Flow is equivalent to that of a 0.05-in. orifice. Operating current is 0.5 to 1.5 amp. The 0.19-lb, 3%-in.-high valve has a life expectancy of up to 100,000 cycles. Valve 872458, the "fastest", uses dry air and nitrogen gas as operating fluid. It has a range of 80 to 3250 psi. Its temperature range is —65 to +160 deg F, and the flow factor is 1.37. Response time is 0.018 sec.

Write in No. 245 on Reader Service Card

MOISTURE MONITORS for high-pressure



The Type 26-350 series of high-pressure moisture monitors are capable of rapid and accurate measurement of trace quantities of moisture in gases, gaseous mixtures, and vapors at sample pressures up to 10,000 psig. Instruments in the series are ideally suited for verifying the dryness of bottled breathing oxygen, for checking compressed air, and for testing moisture in pneumatic control systems and bottled cylinder gases, says Consolidated Electrodynamics Corp., Dept. S/A, 300 N. Sierra Madre Villa, Pasadena, Calif.

Each instrument is equipped with built-in high-pressure regulator, highand low-pressure sample bypass, adjustable flow-control system, and plug-in electrolytic cell, which can be removed or replaced in seconds.

Write in No. 246 on Reader Service Card more on page 246

IN A SQUEEZE?



HERE'S YOUR ANSWER FOR PRECISION TUBING AT REGULAR TUBE PRICES

Quality specifications and profit margins have you in a squeeze on tubing? Precision Tubing assures you unsurpassed quality of temper, straightness, accuracy, finish and roundness at regular mill prices . . . and test results prove it.

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For improved quality at lower costs specify Precision Tubing. Write for technical data to Dept. 10, Precision Tube Company, Inc., North Wales, Pa.



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Bulletin: DM is MS...

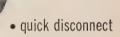
Now you can freely design these advanced push-pull miniatures into your application because the Deutsch DM Series is built to meet this new miniature connector Mil Spec.

Loaded with special Deutschdeveloped features, these environmental miniatures have been proved under the punishing conditions of more than one hundred major electronic systems for military and commercial use.



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- unique ball-lock coupling
- · moisture sealed
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- operation to 250°F.



The Deutsch Company

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Understandably unwelcome in King Cold's domain . . .

Heating Blankets and other Woven Heating Elements by SAFEWAY can make your for problems OLD problems!

Be it the frigid altitudes at which manned aircraft fly, the cold, trackless space domain of missile and satellite, or the icy arctic wastes of DEW Line installations — it's always "winter" somewhere.

Environmental temperature problems common to this kind of "winter" beset fuels and lubricants and hamper the operation of many types of sensitive equipment.

But SAFEWAY dispels such problems by packaging controlled heat for application everywhere. Among the wide variety of heating blankets and woven-wire

heating elements which have been engineered by SAFEWAY to meet exacting specifications are:

- heating elements for launching equipment and for airborne gyros, cameras, computers, servos and batteries — for missiles or aircraft
- de-icing units for airfoil surfaces
- heating elements for all types of ground support equipment
- defrosting units for industrial and commercial refrigeration
- heating blankets for honeycomb and metal-to-metal bonding

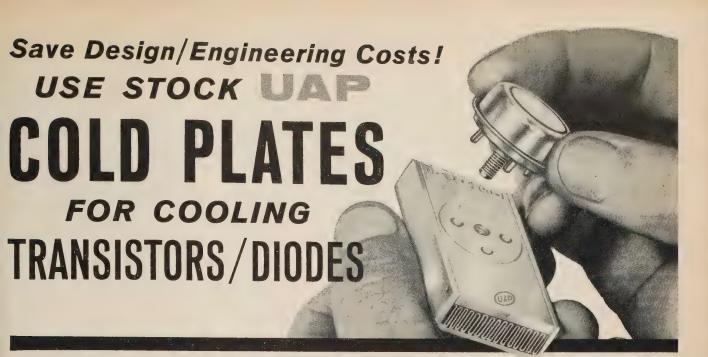
For your copy of a fact-filled folder, please write:

If it has to be heated (and the "it" can be just about anything), you can rely on SAFEWAY engineers to study your problems carefully, and — without any obligation — submit an appropriate recommendation. Safeway

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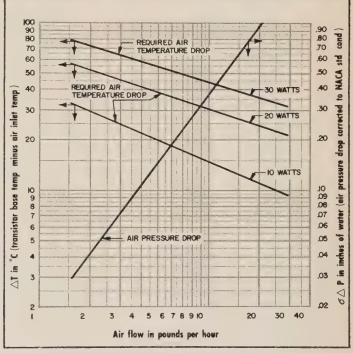
JEDEC* Nos. Transistors TO-3; TO-6; TO-10; TO-13; TO-14; TO-15; TO-26; TO-31; Diodes DO-4; DO-5.

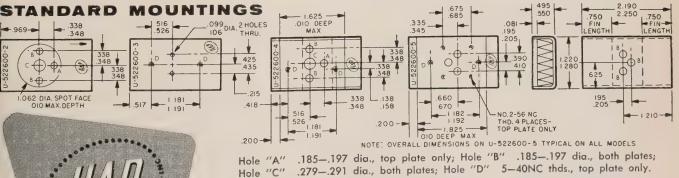
*Joint Electronic Device Engineering Council

Now, you can use *stock* UAP aluminum cold plates to control heat generated by power transistors and diodes used in electronic circuits. Heat is transferred by conduction through the mount to cooling air forced through the cold plate. Cooling air can be ducted from any suitable source.

Adaptability of this cold plate to specific cooling requirements can be easily determined. The maximum allowable transistor or diode base temperature and dissipation must be known or calculated. Then, using any one of the three parameters on the curve, the remaining conditions are indicated. Example: Using a transistor base temperature of 71°C at a dissipation of 20 Watts, and assuming air inlet temperature of 36°C, gives a \triangle T of 35°C, an air flow of 6.4 lbs./hr., with .20 inches of water pressure drop.

Overall envelope dimensions are 2.250" length, 1.280" width, .550" depth. Weight, approximately 1 oz. Finish, alodine. For complete information on prices and delivery, call, wire or write direct to UAP.





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Over 340 models with 1300 designs give the aircraft designer the flexibility of custom fans with the economy of standard fans. Horsepowers as low as 1/500th, fan efficiencies as high as 86%, and pressures up to 70" WG are available.

Joy Axivane Fans meet most applicable government specifications being used by a majority of airframe and missile manufacturers, including Boeing, Lockheed, Martin, Douglas and North American. Joy Axivane Fans have only three basic parts, and motors are flange mounted inside the fans to permit mounting in ducts. This simplicity of design makes the fans lightweight and compact, yet vibration and shock resistant.

Special designs to meet unusual requirements also can be furnished to your specifications. Whatever your air movement problems, Joy can provide the solution. Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa. In Canada: Joy Manufacturing Company (Canada) Limited; Galt, Ontario.





WORLD'S LARGEST MANUFACTURER OF VANEAXIAL TYPE FANS

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400 CYCLE MOTOR has four-pole field

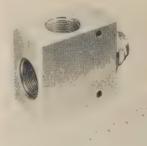


This 115 volt, 400 cycle a-c single phase motor has a four-pole field and is designed for aircraft and missile applications using such power systems. The "Aylo" motor passes MIL-M-7969a qualification tests. Motor life is approximately 100 hours. Built-in 400 cycle magnetic brake has minimum life of 300,000 cycles, says Barber-Colman Co., Dept. S/A, Rockford, Ill. Two balanced windings permit reversal with a SPDT switch. Rated horsepower .020; ambient

Rated horsepower .020; ambient temperature range -65° F to 250° F; weight, including explosion-proof enclosure, .89 lb; size 1.50" x 3.09".

Write in No. 247 on Reader Service Card

RELIEF VALVE is externally adjustable



This large capacity relief valve to control pressure in hydraulic, lubricating and fuel systems is pilot operated and chatter free. Capacity is 130 gpm. Externally adjustable pressure range of 50 to 1,200 psi. Pressure rise is 15 psi at 55 gpm. Negligible variations in the pressure rise and hysterisis curves. Cartridge type design permits overhaul without disconnecting lines and fittings, says Fluid Regulators, Dept. S/A, 313 Gillette St., Painesville, Ohio.

Internal leakage at max. pressure is 5 cu. in./min. maximum. External leakage is zero. Weight is 4 lbs 11 oz, and the unit is designed for 3000 psi proof pressure and above 4000 psi burst pressure.

Write in No. 248 on Reader Service Card more on page 250



How to remotely adjust valve positions with 18000° rotation and .00055% accuracy. Or...

how to put a remote control system in 1/9 the space and save 54%-60% on weight. Or, get 95% efficiency in a 90° bend. Or, design around any bend without intermediate links or pulleys for precision response far beyond the range of any other control system.

The "how" is with TELEFLEX® systems. The "why" is the exclusive TELEFLEX helix wire cable design. No remote control cable anywhere gives such high sensitivity and response... such a reduction in weight and backlash... such design freedom with straight line, angular and unlimited rotary motion!

The technical advances made possible with TELEFLEX cable mean that TELEFLEX engineers have gone further and can offer more in the development of complete mechanical control systems for any purpose. Write for our new catalog . . . or help on your specific problem. TELEFLEX Incorporated, North Wales, Pennsylvania.

TELEFLEX SYSTEMS offer unequaled design flexibility because they are the only systems to offer all three types of mechanical motion...



TELEFLEX

DELCO RADIO

NEW POWER TRANSISTORS



MILITARY-COMMERCIAL

	2N1168	2N392	2N1011	2N1159	2N1160
V _{cb} max.	50	60	80	80	80 volts
I _c max.	5	5	5	5	7 amp.
I _{co} (V _{ec} 2 volts) Typical 25°C.	65	65	65	65	65 μ α.
HFE (3 amp.)	_	60-150	30-75	30-75	_
HFE (5 amp.)	-	_	_	_	20-50
AC Power Gain (I _c =0.6 amp.)	37 DB	-		-	_
V _{ceo} (I _c = 1 amp.)	40 typical	50 typical	60 min.	60 min.	60 volts min.
Thermal Gradient max.	1.5	1.5	1.2	1.2	1.2°

Delco Radio rounds out its power transistor line with this new 5-ampere germanium PNP series. Types 2N1168 and 2N392 are specially designed for low-distortion linear applications, while 2N1159 and 2N1160 are outstanding in reliable switching mode operations.

Type 2N1011 is designed to meet MIL-T-19500/67 (Sig. C). It joins 2N665, MIL-T-19500/68 (Sig. C); 2N297A, MIL-T-19500/36 (Sig. C) and JAN2N174, MIL-T-19500/-13A to provide a selection for military uses.

Write today for engineering data on Delco Radio's line of High Power Transistors.

See you at the WESCON Show, Booth No. 114



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Wherever high-pressure pneumatics are used, the APCO series of high- and ultra-high pressure regulators provides the ultimate versatility for instrumentation and service systems applications. APCO Servo Loaders accept the highest inlet pressures - provide the widest range of precise outlet pressures...are easily adjusted through a low-torque planetary

> gear handle or a 28 V DC actuator. Available with either 4-inch tube or 4-inch NPT threaded ports - valve and filter may be removed for inspection, cleaning, or replacement without disconnecting the regulator from its system! . . . Write today for technical data.

... the most versatile high-pressure regulators available

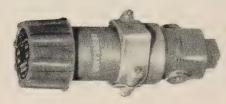


110400

- Extreme accuracy in control
 - Inlet pressure 6000 psi
 - · Regulated outlet pressure in specified ranges



- 110700 Maximum handle torque 35 lb-inch
 - Regulated inlet pressure 6000 psi
 - · Regulated outlet pressure -150 to 5000 psi



- All stainless steel construction in flow area - cleaned for LOX
- Inlet pressure 6000 psi
- Regulated outlet pressure -as specified



117300

- Maximum handle torque 50 lb-inch
- Inlet pressure 10,000 psi
- Regulated outlet pressure -100 to 8000 psi

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616 West Whittier Blvd., Whittier, California Phone OXford 3-3747

Write in No. 272 on Reader Service Card at start of Product Preview Section

10,000 P.S.I. SOLENOID VALVES



They are available for immediate delivery (in stock) at standard valve prices, for a service which generally requires costly (made-to-order) special valves.

Shut off and 4-way valves in ¼, ¾ and ½ inch port sizes are rated for 10,000 P.S.I. liquid or gases. They will withstand surges of up to 15,000 P.S.I. without damage to the valves' sealing qualities (designed for a burst pressure of 30,000 P.S.I.).

Solenoids are available for 115, 230 and 460 volt A.C. operation.

Long maintenance-free service is achieved through the leak-proof "Shear-Seal" design. Optically flat metal to metal sealing surfaces (of the self-aligning sealing rings and the mating rotor face) are protected by staying in constant intimate contact: flow is always through the center of the "Shear-Seals," never across sealing surfaces. Sealing qualities actually improve as the seals lap themselves to a more perfect fit with each valve operation. There is no external shaft leakage because the pressure is confined to the flow passages.

For complete data write for catalog S-10000.



5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA Write in No. 273 on Reader Service Card

LEAD AND TERMINAL for high voltage

A new lead and terminal for high altitude and high voltage, in 12,000, 25,000 and 35,000 V ratings at five amps, is announced by Capitron Div., AMP Inc., Dept. S/A, Harrisburg, Pa. The leads, made of silicone rubber insulated wire, are available in lengths of three inches to any desired length. The terminal is made of epoxy and glass fibre or ceramic materials, depending upon performance specifications.

No special tools are required in its application. It is unusually compact in size and light in weight. Rapid disconnect or assembly and positive reliable alignment or mating of wires, it is said, make this connector particularly suited for missile, and aircraft applications.

Write in No. 412 on Reader Service Card

FERRITE'S FLUX DENSITY exceeds 5000 gauss

The Type W-07 power ferrite, having a maximum flux density at 10 oersted of 5000 gauss, has exceptionally low hysteresis and eddy current losses. Outstanding performance is maintained at frequencies from 400 up to 15,000 cps, says Allen-Bradley Co., Dept. S/A, 136 W. Greenfield Ave., Milwaukee 4, Wis.

The ferrite has a high Curie point of 208 deg C, and the flux density does not decrease appreciably with an increase in temperature. Initial permeability is 1300, maximum is 4000. Residual magnetism is 1000 gauss. The coercive force is 0.24 oersted at a test frequency of 1.5 kc and a temperature of 25 deg C.

Write in No. 413 on Reader Service Card

TV CAMERAS for rugged conditions

Extremely high acoustic noise, shock, vibrations, or even explosions will not prevent this closed-circuit television camera from supplying a high-quality picture. The camera's ruggedness makes it ideal for installations on test stands for rockets and jets, in missile launching areas, wind tunnels, etc., according to Allen B. Du Mont Laboratories, Inc., Dept. S/A, 750 Bloomfield Ave., Clifton, N.J.

Inc., Dept. S/A, 750 Bloomfield Ave., Clifton, N.J.

Two models, both measuring 3¼x3½x10½ in., are available: TC-200-RT is a transistor type, and TC-200-RS contains subminiature tubes. A building-block design lends additional versatility to the camera, which can be remotely operated over a distance of up to 2000 ft. Careful shielding and filtering eliminate interference over that distance.

Write in No. 414 on Reader Service Card

VALVE simplifies servicing

A relief valve that is made in pressure ranges to 5000 psi and is designed for high flow and high temperature applications can be reset or serviced without removal from the line, says Republic Mfg. Co., Dept. S/A, 15655 Brookpark Rd., Cleveland 35, O. External adjusting nuts permit adjustment over the entire range, and the unit contains only one packing, an O-ring, which is easy to replace with the valve still in the line.

The valve is made with either standard 37-deg flare or flareless fittings, in accordance with MS 33656 or MS 33514, respectively, and is available in tube sizes 8 and 12. The standard unit has a range from -65 to +160 deg F, but an upper limit of 400 deg maximum may be obtained through use of a special O-ring.

Write in No. 415 on Reader Service Card more on page 253



Dyna-Soar (for dynamic soaring) is a joint project between the Air Force and the NASA, and is an attempt to solve the technical problems of manned flight in the sub-orbital regions. Advance knowledge on the project indicates how a boost-glide vehicle can operate from the outer fringes of the atmosphere where it can maneuver and be recovered undamaged. Studies show that by varying the original rocket boost,

and thus the velocity, and with the control available to the pilot, the Dyna-Soar aircraft can circumnavigate the earth, followed by a normal and controlled landing. Boeing Airplane Company, one of the competing companies for the development contract for the complete boost-glide system, has delegated to RCA the responsibility for the development of important electronic components of Dyna-Soar.



RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS
CAMDEN, N. J.



Experience and facilities are both at your command when you enlist Fruehauf's assistance in the ground handling portion of your military equipment contract.

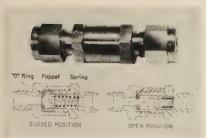
Fruehauf's unparalleled experience has been gained over a number of years on an almost staggering number and variety of ground handling projects. These include research, design, and production of containers or transporters for many types of missiles . . . of numerous missile launchers . . . missile guidance shelters . . . shelters for radar and electronic equipment . . . specialized tank-trailers for military fuels...powder haul vans... mobile containers for materials and supplies . . . and over 400 different types of other military vehicles.

Fruehauf's unexcelled facilities include modern, diversified manufacturing plants all across the nation, with automated production lines and some of the most modern precision machinery to be found anywhere in the country today. Facilities also include extensive research and engineering staffs totally devoted to collaboration on ground handling designs and projects with prime contractors everywhere.

Fruehauf's long history as a leading trailer manufacturer has undoubtedly given impetus to its growth as an important source of ground handling assistance. Whatever the nature of your contract, if it contains a ground handling problem by all means consult Fruehauf.



CHECK VALVE for wide pressure range



This new type of poppet check valve, adaptable for use with a wide range of pressures maintains full flow with very low pressure drop. The poppet-type check is simple in design and positive in action. The special type of assembly used eliminates the common problem of chatter, with its resultant wear and leaking, says Nuclear Products Co., Dept. S/A, 15635 Saranac Road, Cleveland 10, Ohio.

The valve is 21/8 in. from end to end, and is furnished in brass, stainless steel, Monel, aluminum, and nylon. Other materials on request.

Write in No. 416 on Reader Service Card

FREQUENCY CONVERTER meets mil specs

This Model PS6001 Frequency Converter meets all requirements of military specifications for ground equipment, has an input of 120V, 60 cycles, and an output of 115V, 400 cycles, 250 W square wave, says Power Sources, Inc., Dept. S/A, Burlington, Mass.

The converter will operate between 30 and +52 deg C, and is not damaged by temperature extremes to -65 and +85 deg C. The unit measures 10½x5x7 in., and weighs 20 lb.
Write in No. 417 on Reader Service Card

RELAY uses 1.5 W

This relay, #325 ST, has deen designed to meet the requirements of airborne and missile applications, per MIL-R-5757B and MIL-R-6106B, (200 deg C or higher on special order), says Electro-Mechanical Specialties Co., Inc., Dept. S/A, 1016 N. Highland Ave., Los Angeles 38, Calif.

The unit operates on as little as 1.5 W, and is available for 400 cycle ac operation internally rectified. It is 11/2x13/4x21/2 in.

Write in No. 418 on Reader Service Card

CONNECTORS up to size zero

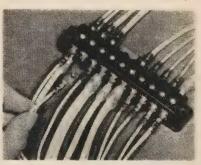


This Seal-E, in a series of MS-E type connectors, is a connector in either pin or socket type, in sizes up to and through size zero, says Connector Seals Corp., Dept. S/A, Rosemead, Calif.

The connector offers the combined advantages of internal connector moisture-proofing by interfacial sealings of application units as created by glass seals.

Write in No. 419 on Reader Service Card

TERMINAL BLOCK has side entry



The addition of a side entry terminal block to their line of electrical connectors is announced by Twin Lock, Inc., Dept. S/A, 1024 West Hillcrest Blvd., Inglewood, Calif. The T-1010, the new block, retains all the inherent advantages of the original T-1000 vertical entry block, it is claimed. The difference is the side entry that allows installation in flat, crowded spaces in which a vertical entry block cannot be used. Any installation requirement can now be met with one block or the other, it is said.

The new block is made of a molded phenolic base with reinforced barriers between the numbered terminal cavities; one cavity will accommodate four terminals. Up to 40 connections can be made with one block. Adjacent terminals can be bussed together with twin lock jumpers. The block measures five inches long, by 1¼ in. wide, by 11/16 in. high. Installation of the lug results in a 50 per cent saving in harness fabrication and installation time when the twin lock block is used, it is claimed.

Write in No. 420 on Reader Service Card

more on page 255

ADVANCED DESIGN FLIGHT ACCESSORY POWER POWER FOR THE X-15 Two G-E auxiliary power units supply vital power in the weightless environment and extreme temperatures found at the edge of space and during re-entry. These compact units provide the North American X-15 with its sole source of power during glide to maximum altitude and return to earth. Each unit drives both an alternator and hydraulic pump, and controls a-c frequency within = 0.5 percent even under extreme hydraulic loads. These new G-E units are designed and tested for a multi-mission endurance life of more than 150 hours. Progress Is Our Most Important Product GENERAL % ELECTRIC

CHECK YOUR PULSE, SIR?

6 ...

"SCOTCH" BRAND High Resolution Tapes deliver a sharper pulse—with fewer dropouts!



In instrumentation, as in life, it's often the pulse-count that counts. So what if your recording impulses are as square as a bar-graph? If your tape only records camel-backed humps, where are you? Probably about due for a change—to "Scotch" BRAND High Resolution Tapes.

Your equipment is somewhat like the proverbial sweater—no matter how advanced, you can only get out of it what you put in. And that calls for "SCOTCH" BRAND High Resolution Tapes—made to deliver improved resolution as pulse density climbs and effective frequencies soar upward to stratospheric heights.

Like so many other advances in tape technology, this superior resolution is a product of 3M research. For one thing, "SCOTCH" BRAND high potency oxides give coatings a higher magnetic retentivity—about a third more than standard. And since the shorter wave lengths of high frequencies are recorded by the surface of the coating, a coating of these potent oxides can be thinner and yet provide equal flux line strength. Results? A flexible tape for intimate tape-to-head contact, a cleaner, sharper recorded pulse.

"SCOTCH" BRAND High Resolution Tapes offer these potent coatings on your choice of two tough polyester backings—158 for standard play, 159 for extra-play. And both are designed to line up your square-waves as densely as a close-order drill, so sharp and clean you'll never miss a bit.

In taping high frequencies, the tested uniformity and dropout-free performance of "SCOTCH" BRAND Magnetic Tapes give the added bonus of reliability. The greater the density of information, the more critical the need for defect-free tapes, and here's where experienced "SCOTCH" BRAND Tape technology really tells.

Whatever your application—data acquisition, reduction or control programming—"SCOTCH" BRAND Instrumentation Tapes supply the reliability you need today and continue to anticipate tomorrow's needs with newer, more sensitive tapes.

In addition to "Scotch" Brand High Resolution Tapes 158 and 159, check the others for your application. "Scotch" Brand High Output Tape 128 offers top output in low frequencies, even in ambient temperature extremes. "Scotch" Brand Sandwich Tapes 188 and 189 end rub-off, build-up, reduce head wear to an absolute minimum, show little wear after 50,000 passes. "Scotch" Brand Instrumentation Tapes 108 and 109 remain the leaders for top performance at low cost.

Where there's no margin for error, there's no tape like "Scotch" brand Magnetic Tape for instrumentation. For details, write Magnetic Products Div., Dept. MBV-89, 3M Company, St. Paul 6, Minn. or mail the inquiry card.

"SCOTCH" is a registered trademark of 3M Company, St. Paul 6, Minnesota Export: 99 Park Avenue, New York, N.Y. In Canada: London, Ontario



SCOTCH BRAND MAGNETIC TAPE

FOR INSTRUMENTATION

MINNESOTA MINING AND MANUFACTURING COMPANY
... WHERE RESEARCH IS THE KEY TO TOMORROW



LAMINATES of epoxy glass

An epoxy-glass laminate, designated T-525 and T-525N, meets Mil-P-18177B, Type GEE, and NEMA-G10. Both forms are available copper clad and non-clad. T-525 copper clad is for normal printed circuit applications; T-525N copper clad will withstand cyanide solutions for gold plating, etc. Printed circuits on T-525 and T-525N can be made flush with adjoining surfaces by using heat and pressure. Standard sheet size 36'' x 42'' and thickness $\frac{1}{32}''$ to 1'' for unclad and $\frac{1}{32}''$ to $\frac{1}{4}''$ for copper clad, according to The Richardson Co., Dept. S/A, 2700 Lake St., Melrose Park, Ill. Other thicknesses and sheet sizes are available.

Write in No. 421 on Reader Service Card

ALTITUDE SWITCHES in expanded line

An expanded line of altitude actuated switches includes three aneroid and barometric switches that are small, light, and have accuracy of setting over wide temperature ranges. The Consolidated Controls, type 6569, 6597 and 6859 altitude switches, feature Ni-Span C capsule material, and offer altitude adjustment ranges of 2,000 to 20,000, and 15,000 to 70,000 ft, says Consolidated Controls Corp., Dept. S/A, Bethel, Conn.

Type 6569 employs two spdt switch elements that can be set to operate at different altitudes. Type 6597 has a relay for dpdt operation. Type 6859, for use in electronic equipment, is an open assembly without cover or electrical receptacle. Calibration accuracy on the four units of 20 mm Hg is maintained under all environmental conditions, including ambient temperature variation from -65 to +250

Write in No. 422 on Reader Service Card

TEMPERATURE INDICATOR for aircraft

A lightweight, transistorized aircraft servo temperature indicator, capable of giving highly accurate readings under all flight conditions, is being developed for the Air Force. Designated type DJ-100, it will be used to measure either pre-turbine or exhaust gas temperatures, depending upon engine requirements, according to the Instrument Dept., General Electric Co., Dept. S/A, West Lynn, Mass. Accuracy within ±5°C in engine operating range is claimed. Combining amplifier and indicator into one unit, the device will be 6" long x 2" diameter and weigh 11/2 lbs.

A CALL ROLL OF TAXABLE A SECTION OF TAX

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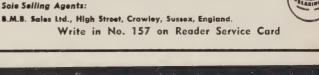
more on page 257



Los Angeles 24, California, U. S. A.

BRITISH MANUFACTURED BEARINGS CO., LTD.

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AIRBORNE RADAR...

The APS-67 Airborne Radar . . . designed and developed by The Magnavox Company in conjunction with the Navy Department, gives eves that see by both day and night to the Crusader.

The APS-67 delivers the utmost in performance and reliability for this Navy Fighter . . . clearly demonstrating The Magnavox Company's ability to produce and work as prime contractor on a complex electronics project.

MAGNAVOX capabilities are in The Fields Of Airborne Radar, ASW, Communications, Navigation Equipments, Fusing and Data Handling . . . your inquiries are invited.



PRODUCTS THAT SEE BY **THEMSELVES**



STATIC INVERTER is transistorized

These transistorized inverters are light and extremely accurate, as compared with conventional rotary inverters, and are available with single- and three-phase outputs, says Gulton Engineered Magnetics, Div., Dept. S/A, 212 Durham Ave., Metuchen, N.J.

The units operate from an input of 28 V dc and provide a dependable accurate output of 115 V at 400 and 2000 cps for single-phase units and of 1.5 V at 400 cps for threephase units. Both inverters have regulation characteristics of ±1% voltage, ±0.02% frequency. Distortion is less than 10%. The units meet Mil-E-5272-A.

Write in No. 424 on Reader Service Card

AIRCRAFT RELAY is hermetically sealed

This hermetically sealed aircraft type relay with AN type connector mounting arrangement makes wiring assembly installation and field service simple, while the connector provides a seal against moisture and assures positive connection. It is called "Diamond H" Series R/S. Extremely sensitive, 4PDT relays with excellent temperature (200° C. or higher), shock (50 "G" or more) and vibration resistance, says Hart Mfg. Co., Dept. S/A, 212P Bartholomew Ave., Hartford, Conn.

The relay is used in missiles, ground and airborne computers, jet engine controls, automation control systems, and similar applications requiring utmost reliability.

Write in No. 425 on Reader Service Card

REMOTE BULB for temperature control

This remote bulb temperature control, type E27A, consists of a liquid-filled bulb, capillary tube and bellows, and a control head. The bellow is attached to the control head and is connected to the remotely-located bulb by means of the capillary tube. Temperature settings are made by rotating a single-turn knob and pointer against a calibrated scale. Models are available with range spans of 100 or 200 deg F between limits of -150 and 650 deg F, and with on-off differentials of about one and two deg F, says United Electric Controls Co., Dept. S/A, 79 School St.,

Watertown 72, Mass.

An adjusting screw is attached to each of two switches so that each switch can be adjusted individually up to a maximum span of about 15 deg F between switch settings. This span is maintained constantly throughout the control range.

Write in No. 426 on Reader Service Card more on page 260

Get FULLY AUTOMATIC PRODUCTION OF FINISHED WIRE LEADS ... any operator can! produce 3,000 or more leads per hour in any insulated wire to 10-ga. END wire stripping bottlenecks! You can measure, cut off and strip insulated wire with this fully automatic ARTOS machine.

some types of wire. With unskilled labor, solid or stranded wire leads are produced in lengths from 2" to 194"— and stripped up to 2" at one or both ends.

over 6,000 leads per hour with

(Left) AE-563 PREFERDER

Completely automatic, self-adjusting unit with 1/3 hp. motor. Requires no attention after wire has been threaded into stripping machine. Heavy reels roll into cradle or can be mounted on a shaft.

ARTOS

MODEL CS-6

ALSO AVAILABLE: Extra equipment to mark leads with any code. Other machines also attach prefabricated terminals in strip form to your wire leads

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EVIDENCE OF OUR CAPABILITY TO MEET YOUR **SPECIFICATIONS**

Take advantage of General Electric's accessory power technologies and research in the

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- Controls
- High-speed equipment
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- Servomechanisms
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FOR MORE INFORMATION, contact Product Information, Aircraft Accessory Turbine Department, Lynn, Mass., or mail this coupon.

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- Jet engine starters ☐ Gas Servomechanisms
 - ☐ Unconventional power
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HRO, THA 15/90 VO

Thanks to the special materials and construction of improved Ketay synchros, the moisture-resistance standards of Mil Spec 20708 (superseding all previous specifications) can be met or exceeded.

Many of these special materials and design features are exclusive with Ketay . . . the only source currently manufacturing and shipping a wide range of the new Mil-type synchros.

Stainless steel housing, shafts, and bearings . . . stators potted in anti-fungus epoxy resin . . . hermetically sealed windings . . . thru-bore construction for fewer parts and less space where moisture can collect . . . these and a variety of other Ketay features all give extra protection against moisture damage.

For high performance and dependability, despite extremes of humidity and temperature, specify Ketay synchros and other precision components, available in production quantities in sizes from 8 to 23. Sixty cycles per second units are available as small as size 15. Units one or more sizes smaller and lighter than previously required can often be used, because of Ketay's superior accuracy. Units of 3' and 2' accuracy are available for immediate delivery.

Ketay engineers are working with manufacturers whose prototype systems have unusual environmental and accuracy requirements. Call or write for help in solving your special problems.

Ketay precision components: SYNCHROS RESOLVERS POTENTIOMETERS SERVO MOTORS TACHOMETERS SERVO AMPLIFIERS

GYROMECHANISMS Catalogues available

NORDEN * Division of United Aircraft Corporation

DEPARTMENT, Commack, Long Island, N.Y.



Computing machines aid language research at Ramo-Wooldridge

To formulate rules for automatic language translation is an enormously subtle and complex project. Yet significant progress is being made. During the past year of research at Ramo-Wooldridge over 60,000 words of Russian text have been translated and analyzed using an electronic computer. From the beginning several hundred syntactic and semantic rules have been used to remove ambiguities that are otherwise present in "word for word" translation. Our present computer program for automatic translation is a considerable improvement over earlier attempts.

Apart from the question of translation itself, electronic computers are invaluable for language research. The expansion of existing knowledge of the rules of language, through statistical analysis, is made practical by mechanized procedures. A clear symbiosis between linguistics and computer technology has emerged.

Automatic translation research is one of many R-W activities addressed to problems of communication of

scientific information. These problems are increasing at an accelerating pace. In this area, as in others, scientists and engineers find at Ramo-Wooldridge challenging career opportunities in fields important to the advance of human knowledge. The areas of activity listed below are those in which R-W is now engaged and in which openings also exist:

Missile electronics systems
Advanced radio and wireline communications
Information processing systems
Anti-submarine warfare
Air navigation and traffic control
Analog and digital computers
Infrared systems
Electronic reconnaissance and countermeasures
Basic and applied physical research

For a copy of our brochure or other information, write to Mr. Donald L. Pyke.



RAMO-WOOLDRIDGE

a division of Thompson Ramo Wooldridge Inc.

FLOW REGULATOR for 3-8 apm

This constant flow regulator for injected water-alchohol applications weighs 1.9 lb. The line size is, inlet, 3/4 in.; outlet, 1/2 in. It requires 24 Vdc at one ampere, max. The regulator operates at temperatures from -65 to +250 deg F. It maintains a constant flow rate regardless of pressure differentials of 30 to 100 psi. The pre-set flow rate is adjustable from three to eight gpm. The unit incorporates a filter, normally opensolenoid shutoff valve, pressure relief valve and reverse flow check valve. It can be modified for pressure differentials up to 3000 psi, says Aero Supply Mfg. Co. Inc., Dept. S/A, Corry, Pa.

This regulator can be made in larger sizes for larger flow rates exceeding 12 gpm. The flow of other liquids such as fuels, hydraulic and lubricating oils can be controlled with this package.

Write in No. 427 on Reader Service Card

FILTER PACK for hydraulic oils

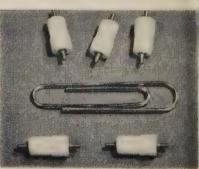


This cellulose filter pack is claimed to prove 99.9% effective in removing particles of all sizes down to practically zero microns from aircraft and missile hydraulic oils, particularly MIL-H-5606A. The "Microcell" was designed for test stands and in hydraulic oil dispensing systems, and it is said to provide the extremely fine micronic filtration needed for more reliable hydraulic systems performance in missiles and aircraft, and in components manufacturing and testing, says Luber-finer, Inc., Dept. S/A, 2514 S. Grand, Los Angeles 7, Calif.

The pack can remove and hold 100 to 150 grams of contaminants from hydraulic oils.

Write in No. 428 on Reader Service Card

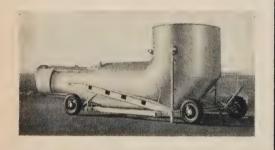
TEFLON TERMINAL is two in one



This double-standoff, Type DST-900 Press Fit, teflon terminal, or two standoffs in one unit, requires only one hole and one insertion, says Selectro Corp., Dept. S/A, 610 Fayette Ave., Mamaroneck, N.Y.

This terminal is two straight shank lugs mounted in a single teflon body, but electrically and physically separated. It is said that such a terminal provides separate connection points on both sides of a chassis and combines the double economy of a single unit and single installation doing the two connection jobs.

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MIXAM PORTABLE JET SILENCERS

Model JEC-10 (shown) is designed specifically for the Douglas DC-8 and Boeing 707. This rugged unit affords a high degree of silencing - without using tie downs.

MAXIM STATIONARY TEST UNITS

Built to match your acoustical requirements. Units are engineered for future internal and external expandability to protect you against obsolescence.

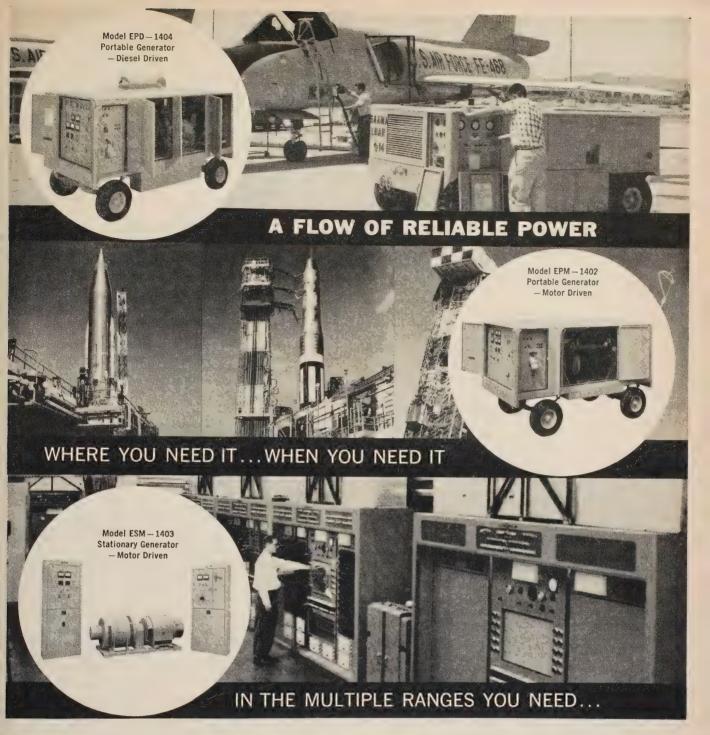
SEND FOR FOLDER, "JET ENGINE SILENCING"



Emhart Manufacturing Company

Maxim Division / Dept. 74

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On the production line of leading airframe manufacturers...at U. S. Air Force bases...and on the remote air strips of our global defense network throughout the world...wherever logistics call for a full-range power supply of absolute reliability you can depend on generating equipment by the Electric Machinery & Equipment Division of American Electronics, Inc. to meet the need. Providing complete versatility with maximum reliability, this rugged, mobile high-frequency generating equipment is precision engineered for checkout of the complete electrical systems of the B-58 and the F-106. It is doing an equally exacting job of checkout and support for other aircraft and weapon systems.

	2401 SERVICING F-106 (top photo right) MULTIPLE VOLTAGES SIMULTANEOUSLY
300 volt DC	3.5 amps.
150 volt DC	7.5 amps.
-140 voit DC	4.5 amps.
28 volt DC	75.0 amps.
28 voit DC	100.0 amps.
115/200 volt	400 cycle 20 KVA
115/200 volt .	
	400 cycle 5 KVA

Write for brochure detailing full particulars



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EME 59-1

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the major source for telemetering systems and components, offers you a unique opportunity to fully use your ability with a rewarding future as a qualified engineer.

Have you had two or more years experience in the design of VHF or UHF transmitters?

... in airborne packaging?

... in transistor circuitry?

If you have, we want to talk to you.

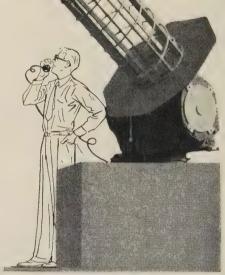
Please send resume to W. C. WALKER ENGINEERING EMPLOYMENT MANAGER



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Other High-Level Electronic Engineering Positions Available

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check the spec



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MINIATURE ALTITUDE SWITCH

AMBIENT ABSOLUTE PRESSURE SWITCH (type GB300*)

- **✓** WEIGHT
- ACTUATION SETTING RANGE OF TESTED AVAILABLE MODELS
- ✓ ELECTRICAL RATING
- ✓ TEMPERATURE RATINGS AVAILABLE
- ✓ VIBRATION RATINGS
- ✓ EXPLOSION RATINGS

UP TO 25G

TO SPECIFICATION

5000 to 60,000 feet or 25 to 1 PSIA

SPDT 18-30 VDC 2.5A Ind.

-65 to 160F

-65 to 275F -65 to 400F**

5-500 5-2000 CPS

MIL-E-5272A

*Switches can be supplied either factory preset or with means for external adjustment.

**Presently undergoing test.



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STAINLESS!



-from inlet to tip

Now the superlative Mastergauge is available in a wider range of corrosion resistant tubes and sockets than any other pressure gauge. Check the adjoining list. And

remember that tube socket and tip are fused into one piece by the exclusive Marsh "Cono-weld" process.

Marsh alone combines the "Conoweld" construction, the copper-clad "Marshalloy" case, the finer Mastergauge move-ment, the Marsh "Recali-brator", the new "Safecase." brator", the new Satecase. Ask for data covering your specific needs.



SIX CHOICES of tubes and sockets

4130 alloy steel tube with alloy steel tip and socket.

403 stainless steel tube with alloy steel tip and

403 stainless steel tube with 416 stainless tip and socket.

316 stainless steel tube with alloy steel tip and socket.

316 stainless steel tube with 303 stainless tip and socket.

"K" Monel tube with alloy steel tip and socket.

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Dept. 43, Skokie, Ill. • Marsh Instrument & Valve Co., (Can.) Ltd. • 8407 103rd St.,
Edmonton, Alberta • Houston Branch Plant: 1121 Rothwell St., Sect. 15, Houston, Texas



Write in No. 281 on Reader Service Card

SPACE/AERONAUTICS

Materials Memo

3M reports on SNAP III . . . heat reflective tape . . . adhesive welding

Many of the 27,000 different products manufactured by Minnesota Mining and Manufacturing—the 3M Company—have proved valuable in missile manufacturing and space research. Here is information on newer products . . . and up-to-date ideas and applications for some established products:

SEEBECK & PELTIER, 1959: Over 100 years ago, in 1829, the German physicist, Thomas Seebeck, discovered that heat applied to one junction of two dissimilar metals in a circuit would produce an electrical potential. The reverse of Seebeck's effect was discovered in 1834 by Jean Peltier when he found that a current passed through the junction of two dissimilar conductors caused heat to be absorbed or given off. Because of the poor conversion efficiencies of available materials, applications of these principles have, until recently, been limited to temperature measurements. But about 10 years ago, a major breakthrough led to the development of new and more efficient conductor materials. Now the Seebeck Effect is headline news: The 1959 development of the first working thermoelectric generator, SNAP III, designed and built by 3M for the Martin Company and the AEC. This unit directly converts heat of radioactive material into electrical energy. Depending on the isotopes used, a 5-lb. generator could provide 5 watts of electricity for one to many years. For comparison, 1,500 lbs. of batteries would be needed to supply 5 watts for one year. Peltier's principle, on the other hand, has led to development of a new 3M Heat Pump. Because of the wide-spread interest in these materials, we now offer a test kit that will let you experiment with heat pumps yourself. Kit contains an assembled Model E-8



heat pump; four extra "P" type elements; four extra "N" type elements; complete instructions—is available for \$75. Send your purchase order to Electrical Products Division, 207-1, Dept. 1442, 3M Co., 900 Bush Ave., St. Paul 6, Minn.

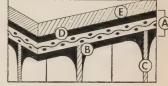
HOT TEMPERED TAPE: One of the latest of the more than 370 pressure-sensitive "SCOTCH" Brand Tapes has unusually good heat-reflective properties. No. Y-9014 can protect plumbing and other hardware from high intensity radiant heat; protect thermally sensitive materials from 5000° F. radiation for short periods. Basic construction is glass cloth laminated to highly-reflective aluminum foil, with a specially compounded pressure-sensitive silicone adhesive. It stands up well under continuous duty at 500°. (Under development: Tape that will withstand 800-850° F.!) You can find this tape liberally applied in engine compartments of some of our big-birds. And wouldn't it be useful in and around high-temp air-breathing jet airplane engines? For complete information on this,

or any of the other "SCOTCH" Brand Tapes, call your 3M Industrial Tape salesman, or write: Missile Industry Liaison at the address below.

seen adhesive technology move a long way from animal glue and gooey surgical tapes. Today adhesives are increasingly regarded for structural joining. As examples: Today most helicopter blades are fabricated with structural adhesives. Intricate castings are now being made in several simple parts which are then bonded together to form the whole. Advanced aircraft and Missiles are built with adhesive bonded honeycombs. And 3M research has led the way in these new advances in adhesive technology. Your 3M AC&S salesman will be glad to give you the complete story. "AC&S", incidentally, means "Adhesives, Coatings, and Sealers." There's more

to the operation than just sticking things together!

GREATER BOND AREA: One side of "3M" Composite Adhesive Film (a) is coated with dry filleting epoxy (b).



Under heat, this epoxy turns liquid, wets deep into the honeycomb (c), then cures chemically to a high-strength, solid fillet. Elastomeric adhesive (d) on the opposite side of film, bonds firmly to skin material (e). Sandwich bond has controlled thickness; is tougher and far less messy than previous sandwich construction adhesives.

ABOUT "MIL": 3M's Missile Industry Liaison is a service staffed by technical personnel experienced in rocket propulsion and other phases of space technology. Their job is to translate problems of the aerospace industry to those 3M specialists best qualified to solve them. If you have questions on any of the items mentioned here, or would like to know what else 3M makes—or **could** make—for your needs, write: 3M Company, Missile Industry Liaison, St. Paul 6, Minn., Dept. VAA-89.



DESCRIPTIVE BROCHURE shows cross-sample of 3M Products for missile and space uses. For free copy, write: 3M Co., Missile Industry Liaison, St. Paul 6, Minn., Dept. VAA-89.

"SCOTCH", AND "3M" ARE REGISTERED TRADEMARKS OF 3M CO., ST. PAUL 6, MINN. - EXPORT: 99 PARK AVE., NEW YORK 16. CANADA: LONDON, ONTARIO.

MINNESOTA MINING AND MANUFACTURING COMPANY







data preview

converter-inverters—A 4-page data file describing their Transidyne line of converter-inverters is available from Spectrol Electronics Corp., Dept. S/A, 1704 So. Del Mar Ave., San Gabriel, Calif. The data file has pictures of the various case styles and lists features and specifications of the 4 basic series.

Write in No. 430 on Reader Service Card

AERONAUTICAL RESEARCH—A tenpage, two-color, brochure describing its facilities, capabilities, fields, and management is available from Allied Research Associates, Inc., Dept. S/A, 43 Leon St., Boston 15, Mass. This research and development organization specializes in fields related to the physical and aeronautical sciences.

Write in No. 431 on Reader Service Card

VALVES — Application Data Sheet 100, the first in a series on valve use, is available from Koehler Aircraft Products Co., Dept. S/A, 409 Leo St., Dayton, O. The initial issue of "Fluid Facts" treats valves for handling LOX and other cyrogenics. Blade and ball-type designs are illustrated.

Write in No. 432 on Reader Service Card

ELECTRONIC CABLING – A 4-page booklet "This is Cable Systematics," describing their capabilites and facilities in the field of custom electronic cabling is available from Robertshaw-Fulton Controls Co., Aeronautical and Instrument Div., Dept. S/A, 401 N. Manchester Blvd., Anaheim, Calif.

Write in No. 433 on Reader Service Card

MICROWAVE TESTING—A 160-page catalog describing the Pacemaker line of microwave test equipments is available from Polytechnic Research and Development Co., Inc., Dept. S/A, 202 Tillary St., Brooklyn 1, N.Y. Included are information on their direct reading frequency meters 532-538 and standing wave amplifiers.

Write in No. 434 on Reader Service Card

FORCE MEASUREMENT—Modern industrial techniques for measuring force, weight, and pressure are described in a booklet entitled "Modern Force Measurement," which is available from Electropics & Instrumentation Div., Baldwin-Lima-Hamilton, Dept. S/A, Waltham, Mass. The advantages of electronic force measurement are discussed, as is the application of SR-4 bonded strain gauges in force measurement devices.

Write in No. 435 on Reader Service Card

MAGNETIC TAPE SHIELDS — Data sheet 142 describing a proposed technique for evaluating the effectiveness of shielding magnetic tape is available from Perfection Mica Co., Magnetic Shield Div., Dept. S/A, 1322 N. Elston Ave, Chicago 22, Ill. The report summarizes the ability of Netic Co-Netic shields to preserve the magnetic tape data.

Write in No. 436 on Reader Service Card

UHF-VHF CALIBRATOR—A data sheet on their VHF-UHF frequency calibrator has been released by Control Electronics Co., Inc., Dept. S/A, 10 Stepar Place, Huntington Station, L.I., N.Y. The unit covers the spectrum from 50 Mcs to 11,000 Mcs without tuning controls and has accuracies of ±.005% throughout the entire frequency range.

Write in No. 437 on Reader Service Card

PLUCS—A revised edition of its "Battery & Power Connectors for engine starting," simplifying battery change and general power use, has been issued by Cannon Electric Co., Dept. S/A, 3208 Humboldt St., Los Angeles 31, Calif. Those plugs have been designed for high current capacity and battery disconnect applications.

Write in No. 438 on Reader Service Card

SWITCHES — Precision sealed limit switches designed for use on gun mounts and missile launching platforms have been described in the two-page Data Sheet 152, available from Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill. Both shock-resistant switches, 1EN75-R and 1EN76-R, have an inline plunger actuator and differ only in the position of their miniature plug-in receptacle.

Write in No. 439 on Reader Service Card

INSTRUMENTS — The complete 54-page 1959 Catalog describing their line of electronic instruments is available from Kay Electric Co., Dept. S/A, Maple Ave., Pine Brook, N.J. Equipments include sweep oscillators, noise generators, pulse generators and other miscellaneous instruments.

Write in No. 440 on Reader Service Card

CABLES—A 6-page folder on "Plasticate," wires and cables for electronic services is now available from Chester Cable Corp., Dept. S/A, Oakland Ave, Chester, N.Y. The cables are available in a variety of conducting, insulating, jacketing, shielding, and armoring materials.

Write in No. 441 on Reader Service Card

page bulletin describing Ferrotron ferromagnetic materials, is available from Polymer Corp. of Penna., Dept. S/A, 2140 Fairmount Ave., Reading, Pa. A line of non-memory, inductive electromagnetic core components, these units will operate up to 350 deg. C.

Write in No. 442 on Reader Service Card

THERMOSTATS — A 4-page bulletin #8400 describing the complete line of Stemco bimetal thermostats is available from Stevens Mfg. Co., Inc., Dept. S/A, P.O. Box 1007, Mansfield, Ohio. The units are used in appliances apparatus, electronic and avionic applications.

Write in No. 443 on Reader Service Card

mechanical assembly kits—A new 16-page catalog, TDS 1110-1, giving complete features and specifications on all its electro-mechanical assembly kits, is available from Servo Corporation of America, Dept. S/A, 20-20 Jericho Tpke., New Hyde Park, Long Island, N.Y.

Write in No. 444 on Reader Service Card

FERRITE MATERIALS—Information on their first commercially available microwave ferrite materials can be obtained from Motorola Inc., Solid State Electronics, Dept. S/A, 3102 N. 56th Street, Phoenix, Ariz. By introducing precision quality control throughout the manufacturing process. Motorola stresses the uniformly high quality of the materials.

Write in No. 445 on Reader Service Card

ASSEMBLIES & GEARS—A new, illustrated book on the design, engineering and production of electro-mechanical assemblies and precision gears, has been issued by Atlas Precision Products Co., Dept. S/A, Philadelphia, Pa. Drawings of all types of gear blanks and differentials are shown as well as gears with standard, slotted, flat or inserted hub.

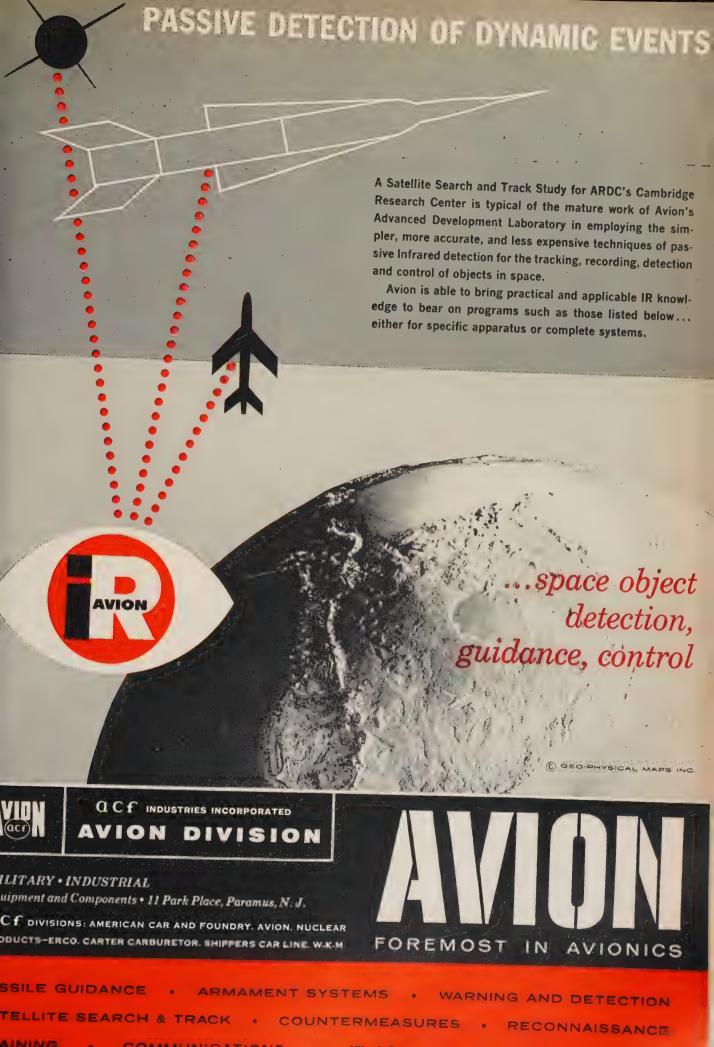
Write in No. 446 on Reader Service Card

PISTON PUMPS & MOTORS—Bulletin No. 5301 gives valuable data on oil hydraulic axial-piston pumps and motors, designed to operate intermittently at pressures up to 1000 psi with monitary overloads up to a maximum of 1500 psi. Dimensions, performance data and specifications are included in this bulletin by Vickers Inc., Dept. S/A, Waterbury 20, Conn.

Write in No. 447 on Reader Service Card

more on page 266

Write in No. 291 on Reader Service Card >> SPACE/AERONAUTICS



Multi-Attitude Mounting system engineered by Federal for flight Data Computer.

Screaming through dives, twisting and turning in violent maneuverstoday's high performance aircraft demand equipment mounting systems engineered for their particular operating regimes.

The Type 1840 Multi-Attitude Mounting System shown above is just one example of Federal's engineered system concept. Designed for service on advanced aircraft, it provides required shock and vibration isolation over specified ranges of operating attitudes. Pressure fittings, electrical connections, or both, to meet requirements.

Like the Type 1840, all Federal mounting systems are engineered specifically for the particular equipment and service conditions. The result is optimum protection, in the minimum package volume.

As specialists in the design of engineered mounting systems to rigorous specifications, Federal welcomes complex shock and vibration isolation problems. A letter outlining your requirements will place our engineering staff at your disposal.

Creating Next Generation Concepts in Vibration and Shock Control

SHOCK MOUNT CORP. 1060 WASHINGTON AVE., N.Y. 56, N.Y.

Data File No. 2 on Federal Engineered Mounting Systems and standard MIL Spec bases and mounts is yours for the asking. Write today to Dept. SA.

FATIGUE TESTING-A brochure has been prepared to describe the equipment used in the fatigue testing service provided for the engineering industry by Short Brothers & Harland, Ltd., Dept. S/A, Queens Island, Belfast, Ireland. Machines employed in testing both material specimens and components have ratings of a 200ton static load down to 50 lbs. SA-601-21R

Write in No. 326 on Reader Service Card

UHF TRANSCEIVER-The operation and characteristics of a single-channel UHF system for emergency and backup use in all high performance aircraft are discussed in a folder released by Bendix Radio Div., Bendix Aviation Corp., Dept. S/A, Baltimore 4, Md. The AN/ARC-63(XA-1) has an emergency battery that automatically cuts in should the aircraft power supply fail.

Write in No. 327 on Reader Service Card

PULSE TRANSFORMERS-The P Series of miniature encapsulated pulse transformers for printed circuit and automatic assembly applications have been described in Technical Bulletin 203 by Technical Engineering Co., Dept. S/A, 1952 E. Allegheny Ave., Philadelphia 34, Pa. The units, which have a high pulse width-to-rise time ratio are available with pulse widths from 0.05 to ten used for either vacuum tube or transistor applications.

Write in No. 328 on Reader Service Card

AIRCRAFT & MISSILE PRODUCTS-

A 12-page brochure covering a wide range of aircraft-missile accessories and subsystems is available from Eastern Industries, Inc., Dept. S/A, 100 Skiff St., Hamden 14, Conn. Bulletin 360, indexed for quick reference and useful to designers, includes specifications and requirements.

Write in No. 329 on Reader Service Card

TANTALUM CAPACITORS - Tables, charts and curves are among the devices used in a 16-page publication to describe wet electrolytic tantalum capacitors made by Fansteel Metallurgical Corp., Dept. S/A, North Chicago, Ill. The booklet discusses the capacitors' capabilities and limitations under various electrical and electronic service conditions.

Write in No. 330 on Reader Service Card

DIGITAL INSTRUMENTS—three lines of digital instruments for measuring ac and dc voltage, voltage ratio, and resistance have been described in the Spring 1959 Short Form Catalog issued by Non-Linear Systems, Inc., Dept. S/A, Del Mar, Calif. Selection guides simplify the choice of instruments and accessories for various applications.

Write in No. 331 on Reader Service Card _ more on page 268 Expanding the Frontiers of Space Technology in

STRUCTURES

Some of the most difficult structure problems in the missile industry were successfully met by Lockheed Missiles and Space Division design engi-neers for the Navy POLARIS FBM-necessitated by the unique launching environment - water

In addition to underwater launching devices, major em-

phasis in structures at Lockheed includes the design of reentry bodies, and thrust termination. Other significant work has been accomplished in diversified aspects of aerodynamic and hydrodynamic load distribution, aeroelastic effects, studies of special dynamic problems arising from aerodynamic disturbances, cavitation, launching conditions and thermal problems relating to analysis of a complex structure taken through a complete timetemperature environment. Important work has been accomplished also in the mechanical design of vehicle frames, flight controls, hydraulic, ignition and separation systems; and in the electrical design of equipment for test, check out, arming and fusing, guidance, and telemetry.

ENGINEERS AND SCIENTISTS

Lockheed Missiles and Space Division programs reach far into the future and deal with unknown environments. If you are experienced in work related to the above areas, you are invited to share in the future of a company with an outstanding record of achievement that spans nearly half a century and make an important contribution of your own to your country's progress in the race for space. Write: Research and Development Staff, Dept. H-16, 962 W. El Camino Real, Sun-nyvale, California. U.S. citizenship required.

Lockheed

MISSILES AND SPACE DIVISION

Systems Manager for the Navy POLARIS FBM; DISCOVERER SATELLITE; Army KINGFISHER; Air Force Q-5 and X-7

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA CAPE CANAVERAL, FLORIDA ALAMOGORDO, NEW MEXICO . HAWAII



A Ryan KDA series turbojet drone slung beneath the wing of a Navy plane. Marman Tail Pipe Couplings are used on this drone.

V-Band Couplings and Tail Pipe ouplings Simplify Assembly Problems



row points to Marman Tail Pipe Coupling supporting the bling shroud of a J-69 engine used on the Ryan Q2C Firebee.

Large diameter tail pipe couplings are used on the Ryan Firebee drone for quick, positive connection of the tail pipe and cooling shroud to the engine. This is one example of how Marman V-Band Couplings are used to simplify assembly of ducting and components.

Marman provides a full range of V-Band Couplings from 1" diameter to 120" diameter, with many standardized sizes available from stock.

Get full information on Marman V-Band Couplings and large diameter tail pipe couplings. Fill in and mail the coupon below.



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The Leader in Rocket Propulsion

ANNOUNCES

Career Positions at Rocketdyne Research Center in

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Disciplines Include:
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Dr. J. Silverman, Group Leader, Chemical Research, Dept 596-FP, Propulsion Field Laboratory, Chatsworth, California

ROCKETDYNE IR

A DIVISION OF NORTH AMERICAN AVIATION, INC.
First with Power for Outer Space

Check Employment Inquiry Form on Page 161



At Astrodyne's plant in McGregor, Texas, this Oliver-Farquhar 2140-Ton Hydraulic Extruding Press does its work in the silence of its own cell, compacting today's powerful solid rocket propellents. All movements of this unique press are programmed and recorded in a central control bunker placed at a safe distance from the unmanned press cell.

Write, wire or phone for complete information or ask for our recommendations and proposals. The Oliver Corporation, A. B. Farquhar Division, Press and Special Machinery Departments, York 10, Penna.

Write in No. 294 on Reader Service Card at start of Product Preview Section

PULSE GENERATOR—Two subassen blies, a pulse generator and the pow supply and signal generator unit, a contained in the Type MR500 VI pulse generator, which simulates varous types of navigational and blir approach transponder beacons, a cording to Data Sheet MR500, available from Murphy Radio, Ltd., Dep S/A, Welwyn Garden City, Hert England. The equipment permit workshop measurement of DME performance and calibration.

Write in No. 332 on Reader Service Cal

BUTTON CELL BATTERIES—Bullet No. VO-110, highlights the feature design, and specifications of the Vous Series button cell batteries — most than 50 distinct sizes and voltage This brochure is published by Gulte Industries, Inc., Dept. S/A, Metchen, N. J.

Write in No. 333 on Reader Service Ca

MISSILE CONNECTORS—Its completed line of missile umbilical plugs is discribed, and its facilities reviewer in a new, 48-page, two-color, illustrated catalog by Cannon Electrico., Dept. S/A, 3208 Humboldt S. Los Angeles 31, Calif. Four bastypes of release disconnect mechanisms are fully described and illustrated to show the principles the effect the remote release of plug arreceptacle.

Write in No. 334 on Reader Service Ca

GEARS — High-performance precising gears, designed for industrial, marria aircraft, missile, radar, and other a plications are described in Bullet GEA-6430, a 24-page, two-color, lustrated brochure, from Gener Electric, Dept. S/A, Schenectady N. Y.

Write in No. 335 on Reader Service Ca

FLEXIBLE HOSE—Silvofled and Flu roflex, two types of flexible hose us ful in engine, aircraft and missi construction, have been described a technical catalog available fro Palmer Aero Products, Ltd., Der S/A, Penfold St., Edgeware Roa London N.W.8., England. Drawing specification sheets and detailed construction data are included.

Write in No. 336 on Reader Service Ca

PRESSURE SWITCHES — Absolut gage, differential and thermal presure switches are the four basic typ described in a 16-page brochure proper selection and a plication of pressure switches, Gorn Electric Co., Inc., Dept. S/Stamford, Conn. Selection factor such as vibration and shock, temper ture, altitude and atmospheric coditions are discussed as well as necessary.

Write in No. 337 on Reader Service Commore on page 2



The F8U-1P Crusader recently set new coast to coast speed record. CAI camera control system with Edison Time Delay Relay was used to automatically provide sharp, clear aerial photographs of the entire flight.

HERE'S WHAT A CUSTOMER SAYS ABOUT EDISON TIME DELAY RELAY...

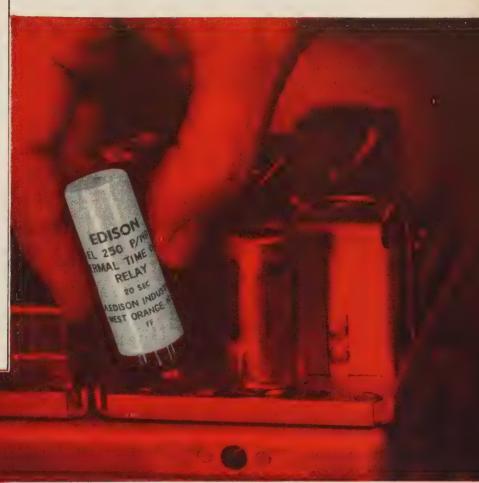
"The CAX-12 servo power unit is a very vital part of the intricate 'brain' of the automatic camera control system, and naturally, we must have absolute reliability in all components. Therefore, as you know, we have relied on Edison Thermal Time Delay Relays since the original design of this CAX-12 and similar units. Since space for this type of equipment is at a premium, the compact size was a most important factor in original selection, but our units must also withstand severe environmental testing, involving vibration, moisture, shock, pressure fluctuation and extremes of temperature. Needless to say, the Edison Relay met all of these exacting requirements in our laboratories, and we've been specifying Edison ever since!"

(The above letter was received from Chicago Aerial Industries)

Jiii ago ii ai ai ii aabii io j

EDISON

Time Delay Relay assures sharp, clear aerial photos... automatically



Edison's Thermal Time Delay Relay being inserted in the CAX-12 servo power unit.

cago Aerial Industries has developed a camera control systhat allows one jet pilot to do the job of ten expert aerial tographers . . . automatically.

rt of this new unit is the CAX-12 servo power unit. Courately synchronizes film speed with speed of the jet—
lages lens openings in response to electronic signals—
lates shutter speed and controls driving motor on cameras.

use this power unit is vital to the camera control system ponent reliability is a must. That's why CAI relies on Edison Thermal Time Relays exclusively for CAX-12.

Edison's line of miniature time delay relays are available for a wide range of electronic applications. They are light, small, rugged and offer these advantages:

- Designed to withstand vibration frequencies to 500 CPS
- Exceptionally high rate of contact closure
- Permanent calibration and hermetic seal
- Extremely rigid mechanical structure using high-strength, high-expansion alloys.

Thomas A. Edison Industries

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EDISON ENGINEERING OFFICES ARE LOCATED IN: CHICAGO; DALLAS; DAYTON; LOS ANGELES

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the newest

le control

onents at 2423

ON Show.

SYSTEMS — Recording and Plotting systems are described and illustrated in a two-color, four-page folder by B. & F. Instruments Inc., Dept. S/A, 3644 No. Lawrence St., Philadelphia 40, Pa.

Write in No. 338 on Reader Service Card

BELLOWS-The first publication giving information on bellows design in this country has been published by Belfab Corp., Dept. S/A, 11 Ramak Circle, Agama, Mass. The "Bellows Design Manual" includes a slide rule, describes procedures, and gives ordering information. Price: \$1.00.

Write in No. 339 on Reader Service Card

TEST POINT CONNECTORS-Technical data on its printed circuit test point connectors is given in an illustrated, six-page brochure by DeJur-Amsco Corp., Dept. S/A, 45-01 Northern Blvd., Long Island City 1,

Write in No. 340 on Reader Service Card

INSTRUMENT BEARINGS-A complete line of thin-section ball bearings, known as T-Series, is described in new 24-page Catalog #59 from Split Ballbearing, Dept. S/A, Lebanon, N.H. New engineering data and applications are included.

Write in No. 341 on Reader Service Card

FUEL MEASUREMENT-Two fuel flow meters, designed to compensate for density variations and minimize viscosity variations, and an integrator incorporated in one of them are the subjects of bulletins prepared by Negretti & Zambra, Ltd., Dept. S/A, 122 Regent St., London, W.1, England. Publications A/18 and 1058 cover the Series 2 flow meter and integrator, respectively, and the other meter is discussed in List A/17. Write in No. 342 on Reader Service Card

RAMIETS-A 20-page brochure discussing theory and application of ramjets has been prepared by Bristol Aero-Engines, Ltd., Dept. S/A, Filton, England. B RJ 1-2 discusses the range of speeds and operating altitudes in a section dealing with the ramjet in aircraft propulsion, and ramjet use in missiles is emphasized.

Write in No. 344 on Reader Service Card

SPEED DRIVES-Catalog 11058 contion, specifications, and applications tains such technical data as descripof its adjustable speed drives. A comprehensive, file-type data sheet is included, as well as schematic diagrams in this catalog from Servo-Tex Products Co., Dept. S/A, 1086 Goffle Rd., Hawthorne, N.J.

Write in No. 345 on Reader Service Card

TERMINAL BLOCK-A data sheet describing its new series 200-19 plug and socket terminal block for heavy duty applications is available from DeJur-Amsco Corp., Dept. S/A, 55-01 Northern Blvd., Long Island City 1, N.Y. Outline and mounting dimensions are also given.

Write in No. 346 on Reader Service Card

SHOCK TESTERS-Bulletin 4-70 describes Shock Testers, precision in-struments for controlled shock simulation, by Consolidated Electrodynamics Corp., Dept. S/A, Rochester, N.Y. This 16-page, two-color brochure covers operation, control of acceleration and deceleration, installation, applications, and equipment, services, and accessories.

Write in No. 347 on Reader Service Card

FUEL CONTROL—Gas turbine hydraulic fuel control systems for Dowty spill nozzles are described in two eight-page brochures available from Dowty Fuel Systems, Ltd., Dept. S/A, Cheltenham, Gloucestershire, England. DF/5/1/AL/957C covers a system for supersonic-type turbines, and DFS/4/1/AM/956/NB considers a single circuit system for aircraft turbines. Both units use a "one piece" design for weight savings and ease of maintenance.

Write in No. 348 on Reader Service Card more on page 272

hush-hush?

If you're now involved, or becoming involved, in hush-hush projects, you know how vital it is to have sources who can deliver on time, to rigid specifications. That's why it's important to constantly investigate and compare new sources — to be sure!

Cleveland Tool and Die Company has the capacity, ability and facilities* to insure your success. We're precision specialists in the manufacture of component mechanisms, sub assemblies, gages and fixtures . . . in custom machining, boring and grinding.

We've performed an important part in such exotic projects as the Shippingsport atomic reactor, the U.S.S. Nautilus, Redstone Arsenal, and Princeton's new synchrocyclotron. When you talk to CTD, you know you're talking to qualified, dependable people.

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DIMAZINE

THE STORABLE FUEL

Performance data on DIMAZINE-powered rocket engines in military missiles and satellite launching vehicles shows DIMAZINE to be a highly reliable rocket fuel.

DIMAZINE provides fast, dependable hypergolic starts followed by smooth, stable combustion and easier shutdowns. Dependable instant readiness is assured for years by its outstanding stability during storage in missiles. It also has high performance, high

thermal stability, low freezing point, low shock sensitivity, minimum susceptibility to contamination and high compatibility with almost all metals and appropriate sealing materials.

These manifold advantages combine to make DIMAZINE the outstanding storable fuel. We will be pleased to work with you in evaluating DIMAZINE and to supply detailed data on its properties and handling.

Putting Ideas to Work

FOOD MACHINERY AND CHEMICAL CORPORATION Westvaco Chlor-Alkali Division

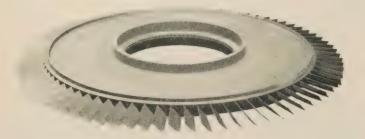
> General Sales Offices: 161 E. 42nd STREET, NEW YORK 17

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UPGRADES GAS TURBINE ROTORS,

STATORS, BLADES AND BUCKETS, DUCT AND FRAME ASSEMBLIES OF STAINLESS OR SUPER ALLOYS



If you require intricate, precision-assembled sheet metal fabrications of stainless steel or super-alloy, your product's quality will be upgraded if the advanced STALKER ORTHOBRAZE PROCESS is used! If your objectives include savings in cost, weight, material utilization, as well as dimensional stability — and especially thermal stability - it will pay you to investigate.

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Write, wire or phone. Brazing design circular upon request. (U.S. Air Force certification for brazing and heat treat)

CORPORATION

905 Woodside Avenue Essexville, Michigan

Phone: Bay City -TWinbrook 3-7562

Write in No. 295 on Reader Service Card at start of Product Preview Section

DATA PREVIEW

BRAZING SHEET-An engineering data sheet, No. 4-A, on 0.005-in.thick flexible brazing sheet for high temperature service honeycomb applications has been issued by Sca nless Processing Div., Wall Colmonoy Corp., Dept. S/A, 19345 John R St., Detroit 3, Mich. It discusses sizes and weights.

Write in No. 349 on Reader Service Card

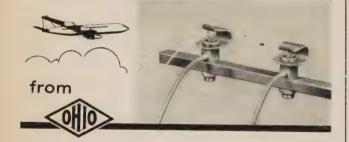
SERVO INDICATOR-Features, applications, and specifications of their digital servo indicator Model 143 are described in Bulletin D-104 by Gilmore Industries, Inc., Dept. S/A, 13015 Woodland Ave., Cleveland 20, Ohio. The model is for fast, accurate indication of forces, fluid flow, weights, and rom's.

Write in No. 350 on Reader Service Card

TITANIUM-A reference for engineers, metallurgists, and designers needing latest technical information on titanium has been prepared by Harvey Aluminum, Dept. S/A, 19200 S. Western Ave., Torrance, Calif. Discussed in detail is the conversion of basic ore into sponge and melting of sponge into ingot form.

Write in No. 351 on Reader Service Card

more on page 274



a new passenger jet aircraft

EMERGENCY DECOMPRESSION **FLOW CONTROL** VALVE

A compact, lightweight valve for installation in the emergency oxygen compartment. Valve stands 1½" above the manifold and is ¾" in diameter. Total weight is 0.8 oz. Can be individually or manifold mounted.

Valve is actuated when mask is removed from compartment by the passenger. It can be quickly and easily reset. Flow characteristics conform with altitude

For complete data and free engineering aid from specialists in aviation oxygen systems, please write to: Aviation Department.



OHIO CHEMICAL & SURGICAL EQUIPMENT CO

(A Division of Air Reduction Company, Inc.)

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AiResearch expansion in electronics and electromechanical activity is creating outstanding positions at all levels for qualified engineers.

FLIGHT SYSTEMS RESEARCH

General problems in motivation and navigation in air and space; required background in astronomy, physics, engineering.

Openings also exist in the following areas: Data Systems Research...Controls Analysis... Flight Data Components... Electromagnetic Development...Instrument Design...Airborne Instrumentation Analysis and Design.

Send resume to: Mr. G. D. Bradley



AiResearch Manufacturing Division

9851 So. Sepulveda Blvd., Los Angeles 45, Calif.

Check Employment Inquiry Form on Page 161

The MISSILE:

U. S. A. F. Northrop's SM-62 Snark, with a range of more than 6000 miles. Now operational, the Snark is America's first intercontinental guided missile. Powerplant is a Pratt & Whitney J-57 turbojet. Guidance is by a stellarmonitored inertial system.

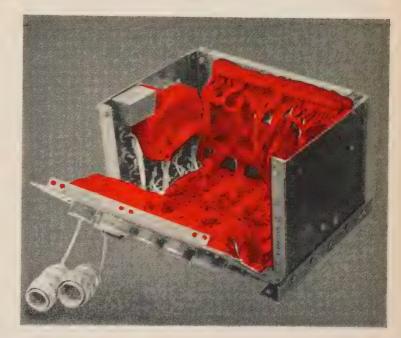


The MATERIAL:

SILASTIC

In the Snark, panels containing resistors, capacitors, transistors and other electronic components are cushioned by Silastic*, the Dow Corning silicone rubber. Silastic protects against moisture, vibration damage, electrical leakage.

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The METHOD:

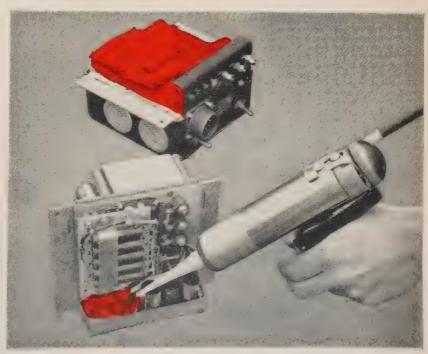
Encapsulating with Silastic RTV, via calking gun. Silastic RTV vulcanizes completely at room temperature. When vulcanized, it has the characteristics typical of Silastic: resistance to extreme temperatures, moisture, ozone, corona. Electrical properties are excellent. Silastic RTV can be slit open for repair work and then re-sealed. Write for sample and technical data.



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Dow Corning

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SPHERICAL

BEARINGS & ROD ENDS

Here's quality you can count on for transmission of motion. SPHERCO solid onepiece race protects the ball from binding and pinching under load and resists shock. vibration and impact. An exclusive SPHERCO method of locking the insert in a rod end body, assures you of a smooth, free running but rugged rod end bearing.



CATALOG 257

SEALMASTER BEARING DIVISION STEPHENS-ADAMSON MFG. CO. 2 RIDGEWAY AVE. . AURORA, ILL.

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CONNECTORS - Zero-leakage connectors for use in exotic fluid applications are described in an illustrated bulletin, featuring test data, and other couplings produced by E. B. Wiggins Oil Tool Co., Inc., Dept. S/A, 3424 E. Olympic Blvd., Los Angeles 23, Calif.

Write in No. 352 on Reader Service Card

NUCLEAR ENGINEERING - The design, engineering, fabrication, construction and testing facilities of Stearns-Roger Mfg. Co., Dept. S/A, 660 Bannock St., P.O. Box 5370, Denver 17, Col., are illustrated in a 12-page colorful brochure entitled "Cryogenics, Nuclear Engineering, and High Pressure Systems"

Write in No. 353 on Reader Service Card

HOSE ASSEMBLIES-Flexible Hose Assemblies of teflon, covered with woven stainless steel wire braid, are described in 16-page, illustrated Bulletin TC-101 by American Brass Co., Dept S/A, Waterbury, Conn. In addition to specifications and diagrams, its facilities and equipment are discussed and ordering information is included.

Write in No. 354 on Reader Service Card

AIRCRAFT-MISSILE PARTS - Equipment, engineering, services, and facilities of Fenn Mfg. Co., Dept. S/A, Fenn Rd., Newington, Conn., are described in a six-page folder. Precision parts made by Fenn are also illustrated.

Write in No. 355 on Reader Service Card

SYSTEMS ENGINEERING—A 28-page, four-color, illustrated brochure covers Western Design & Mfg. Corp., Dept. S/A, Santa Barbara Airport, Goleta, Calif., facilities and personnel for its research, design, development and manufacture for airborne, marine, and ground weapons and vehicles.

Write in No. 356 on Reader Service Card

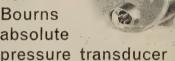
SWITCHES – Thermal Control Co., Ltd., Dept. S/A, Sackville Rd., Hove, Sussex, England, offers literature describing its line of pressure switches and new high pressure switches. Applications and specifications, as well as diagrams are included.

Write in No. 357 on Reader Service Card

FILTERS—The subject of filtration is discussed and its facilities, equipment, and products are described in 112page, illustrated, loose-leaf type brochure by Bendix Filter Div., Bendix Aviation Corp., Dept. S/A, P.O. Box 135, Royal Oak, Mich. Filters for aircraft, missiles, industry, and ground support equipment are featured.

Write in No. 358 on Reader Service Card more on page 276

new Bourns absolute



Miniature potentiometer transducer/35G vibration, 20-2000 cps/High accuracy/ 5-ounce weight

New bourdon tube instrument for telemetering and control of missile, pneumatic, and hydraulic systems. Absolute, gage, or differential pressure ranges available with static error band of ±0.9%. Excellent noise-free low error performance in high vibration and acceleration environments.

725
up to 0-5000 psia
±0.9%
±1.8%
None
1-3/4" D x 3/8"

*Includes friction, hysteresis, linearity, resolution, repeatability

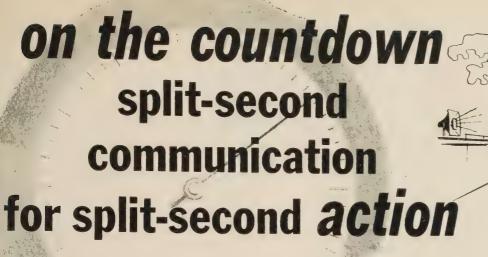
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P.O. Box 2112M, Riverside, Calif. Field Engineering Offices: L. I., New York, and Dallas, Texas

Pioneers in potentiometer transducers for position, pressure and acceleration.
Exclusive manufacturers of
Trimpot*, Trimit*

Write in No. 303 on Reader Service Card SPACE/AERONAUTICS





Launching today's highly complex missiles demands an unprecedented degree of "team" cooperation. Hundreds of scientists, technicians and specialists must be kept constantly informed during the all-important countdown. Instant action-getting voice communications is the best answer.

An urgent call for a key man . . . an important change in fueling requirements...a broken control cable-all require and get instant action over a DuKane "job-engineered" communications system. DuKane systems are today providing these vital functions at Patrick Air Force Base, Fort Churchill, and White Sands.

DuKane's advanced engineering group, backed by more than 36 years of specialized experience in the communications field, is available to help you plan your system. Their experience is your guarantee of the best in communications.

For any missile base ground communications need, write or wire DuKane Corporation, Department SA-4, St. Charles, Illinois.

And, if you specify electronic equipment, ask for DuKane's Electronic Equipment Symbols wall chart . . . no obligation of course. DuKane products are installed and serviced by a nationwide organization of factory-trained experts.

DUKANE CORPORATION St. Charles, Illinois

lob-engineered sound installations...Flexifone intercom systems...Private automatic telephone systems...Hospital communications systems...Ionovac hi-fi tweeters and ultrasonic generators...Sound slidefilm projectors for education and industry... Electronic production facilities for industry and for defense.



ROTARY CONVERTERS — Literatu has been issued to describe sever heavy-duty precision dc-to-ac rotal converters made by Standard Elektr Lorenz AG, Dept. S/A, Hellmut Hirth-Strasse 42, Stuttgart, German Type sheet 134-14-3 E details the 108 Series, useful for feeding ampiers, radio receivers and testing an measuring instruments, and Typ Sheet 134-11-4 E considers a wide variety of similar units.

Write in No. 359 on Reader Service Ca

one Horsepower Motor—A dasheet describing its light weight, on horsepower motor designed for massile application, is available from Hoover Electric Co., Dept. S/A, 216 South Stoner Ave., Los Angeles 25 Calif. This motor is adaptable to wide range of pump or gear bedrive applications.

Write in No. 360 on Reader Service Cal

ELECTRONICS—A 20-page bookle has been prepared to highlight the interests, achievements and produce of Marconi's Wireless Telegraph Collection. Dept. S/A, Marconi House Chelmsford, Essex, England. Communications, both wide and narrot band, navigational aids, airborr radio systems, and data handling at among the many areas considered.

Write in No. 361 on Reader Service Cal

ENGINEERING—Its services, system facilities personnel, and products a described in a 20-page, four-cold illustrated brochure by Sanders Asseciates, Inc., Dept. S/A, Nashua, N.H. Its operations cover research, development, volume manufacturinand marketing of precision parts, an engineering systems for both government and industry.

Write in No. 362 on Reader Service Cake

PRESSURE TRANSDUCER—Four strafgauges bonded to the outer wall of gauge cylinder comprise the rugge pressure transducer described in a information sheet available from Thairey Aviation Co., Ltd., Dept. S/A Hayes, Middlesex, England. Gauge are available to accommodate pressur ranges as great as zero to 8000 psi.

Write in No. 363 on Reader Service Cal

MULTIPLEXER—A unique magneti approach to low-level multiplexing it telemetry and flight test application has resulted in a high-speed, extremely sensitive multiplexer capablof sampling low-level voltages a rates up to 5000 channels per sec, according to Bulletin 200-M, available from Cubic Corp., Dept. S/A, 557. Kearney Villa Rd., San Diego 11 Calif. A 1000- channel version of the multiplexer occupies 12 cu in. and weighs five lbs.

Write in No. 364 on Reader Service Can

more on page 27



AND NOW... Honeywell's new silicon transistorized xhaust gas temperature system designed to MIL-I-27209

ne result of four years of intensive development, Honeyell's new JG 533 Exhaust Gas Temperature Measuring estem is now available for military and commercial jet owered aircraft. Designed to MIL-I-27209, and accurate to st than ½ of one percent, Honeywell's new indicator prodes dependable, maintenance-free temperature monitor-

ing. Here at last is a complete silicon system for monitoring, analyzing, recording and integrating engine temperature parameters. It is backed by a service history of over 2,000 operational EGTI systems, plus 74 years of control experience. For technical information, call or write Honeywell, Dept. 671, 2600 Ridgway Road, Minneapolis, Minnesota.

Honeywell



Write in No. 306 on Reader Service Card at start of Product Preview Section



· AiResearch Central Air Data Computer for North American's A3J, Navy's firs weapon system, provides information dealing with bombing, navigation, engine inler control, radar, automatic flight control and cockpit instrumentation.

Expansion in electronics and electromechanical activity is creating excellent openings at all levels for qualified engineers. Diversified programs include Central Air Data systems on Air Defense Command B-70 and F-108, North American A3J and McDonnell F-4H, as well as other commercial and military aircraft and missile projects.

Openings in the following areas:

- lems in motivation and navigation in air and space; required background in astronomy, physics, engineering.
- DATA SYSTEMS RESEARCH Experience with physical measuring devices using electromagnetic, atomic, thermionic and mechanical approaches.
- CONTROLS ANALYSIS Work in preliminary design stage involves servomechanisms analysis and analog computer techniques.
- FLIGHT DATA COMPONENTS Analysis proposal, design and development work in the following specialties: circuit analysis, servo theory, transducers, transistors, airborne instrument and analog development of high and low temperature problems.

- FLIGHT SYSTEMS RESEARCH General prob- ELECTROMAGNETIC DEVELOPMENT Work with magnetic amplifiers requires knowledge of electromagnetic theory, materials and design methods.
 - INSTRUMENT DESIGN Electromechanical design of force-balance instruments, pressure measuring devices, precision gear trains and servo-driven positioning devices. Experience in electrical and electromagnetic transducers desirable
 - AIRBORNE INSTRUMENTATION ANALYSIS AND DESIGN Work involves solving problems in accuracy, response and environmental effects.

Send resume to: Mr. G. D. Bradley

THE GARRETT CORPORATION AiResearch Manufacturing Division

9851 SO. SEPULVEDA BLVD., LOS ANGELES 45, CALIFORNIA

UHF DEVICES-Literature covering a UHF wideband receiver, wideband directional coupler, and a single pole double breaking switch for aircraft use has been prepared by Sir W.G Armstrong Whitworth Aircraft, Ltd. Dept. S/A, Baginton, Coventry, England. The receiver has a 420 to 470-mc range and is available with overall bandwidths of four or six mc The coupler will measure RF power and SWR in coax cables, and the switch will withstand high shock and vibration.

Write in No. 365 on Reader Service Card

ALLOY-An alloy that is used extensively in the guided missile and allied fields is the subject of a comprehensive 32-page brochure available from The Tungum Co., Ltd., Dept. S/A, The White House, Arle, Cheltenham, Gloucester, England. Machining, heat treating and soldering are among the handling details offered on Tungum Alloy, which is resistant to salt-water corrosion, acids, and atmospheric conditions.

Write in No. 366 on Reader Service Card

ELECTRONICS—A brochure has been prepared to present a brief account of the electronic interests of Compagnie Francaise Thomson-Houston, Dept. S/A, 173 Bd. Haussmann, Paris 8, France. The company is concerned with radar and microwave systems, missile guidance systems, semiconductors, nucleonics, and other areas.

Write in No. 367 on Reader Service Card

CABIN COOLING-Two pages of information on a vapor cycle cooling system for air conditioning aircraft cabins have been presented in Leaflet XN 31, available from Normalair, Ltd., Dept. S/A, Yeovil, England. Systems may be obtained with several compressors, including six and 30-t types, and the latter weighs about

Write in No. 368 on Reader Service Card

PRECISION MOTORS—Data sheets on several small, precision servo motors for radar, electronic and other uses have been compiled in folder form by S. G. Brown, Ltd., Dept. S/A, Shakespeare St., Watford, Hertfordshire, England. The motors include six-pole, two-phase, squirrel-cage, induction types.

Write in No. 369 on Reader Service Card

POWERED CONTROLS—Two booklets on powered flight controls, which give pilots an assist in maneuvering high performance aircraft, have been issued by Boulton Paul Aircraft, Ltd., Dept. S/A, Wolverhampton, England. One concentrates on operation and advantages of various systems and the other examines several equipments.

Write in No. 370 on Reader Service Card

more on page 280

"BECCO

Hydrogen

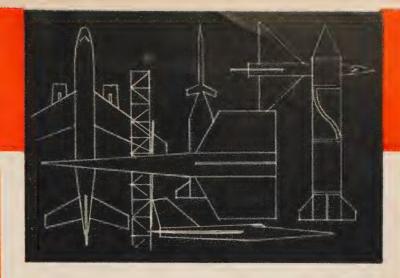
Peroxide

has met

performance

requirements'

-reports General Electric Company's Flight Propulsion **Laboratory Department**



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- "2. Deliveries have never failed to meet our specifications.
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MINIATURE AGASTAT® time delay relay

for missile, aircraft and electronic applications

INSTANTANEOUS RECYCLING ... reset time—less than .020 seconds

UNAFFECTED BY VOLTAGE VARIATIONS ... time delay remains

AGASTAT

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AA De

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constant from 18 to 30 volts DC

ADJUSTABLE . . . time delays from .030 to 120 seconds

CHOICE OF OPERATION...for either energizing or de-energizing SMALL... height $-4\frac{5}{8}$ "... width $-1\frac{13}{6}$ "... depth $-1\frac{1}{2}$ "

LIGHT ... maximum weight—15 ounces

MEETS ENVIRONMENTAL REQUIREMENTS OF MIL-E-5272A

This new AGASTAT time delay relay is an externally adjustable, double-pole, double-throw unit. It incorporates the basic AGASTAT timing principle, proved by a half-century of reliable operation on automatic aids to navigation, in a space-saving miniature unit built to withstand the rugged environmental conditions of missile and aircraft applications.

For specific information on the new AGASTAT relay for your application, write to Dept. A30-819



ELASTIC STOP NUT CORPORATION OF AMERICA

1027 Newark Avenue, Elizabeth, New Jersey
Pioneers in pneumatic timing

Write in No. 309 on Reader Service Card at start of Product Preview Section

TOTAL TEMPERATURE PROBES PITOT-STATIC TUBES





Minneapolis 24, Minn.

Write in No. 310 on Reader Service Card



Write in No. 278 on Reader Service Card

SWITCHES—A four-page Data Sheet 151 available from Micro-Switch Div., Minneapolis-Honeywell Co., Dept. S/A, Freeport, Ill., describes new, light, snap-action, sealed high temperature and shock resistant type switches for use in aircraft, missiles, and missile ground support equipment. Electrical ratings, characteristics, and drawings are included.

Write in No. 371 on Reader Service Card

converters—Performance data on its liquid oxygen converters for oxygen and nitrogen systems, is included in folder F-1250 from Linde Co., Div of Union Carbide Corp., Dept. S/A, 30 E. 42nd St., New York 17, N.Y.

Write in No. 372 on Reader Service Card

PROGRAMER—AR-118 is an information sheet describing a new automatic programing system for the Model G-15 digital computer made by Bendix Computer Div., Bendix Aviation Corp., Dept. S/A, 5630 Arbor Vitae St., Los Angeles 45, Calif. The POGO system enables personnel with relatively little computer experience to write highly efficient computer programs.

Write in No. 373 on Reader Service Card

ENVIRONMENTAL EQUIPMENT—Weber Mfg. Co., Inc., Dept. S/A, P.O. Box 217, Indianapolis 6, Ind., has an illustrated, 28-page, brochure offering specifications, technical data, and applications of its complete line of environmental chambers. Included are charts on high altitude, atmosphere and temperature conversion, tables on altitude conversion and relative humidity, and schematic diagrams.

Write in No. 374 on Reader Service Card

ANTI-FRICTION BEARINGS—A fourpage brochure describing a recirculating, anti-friction way bearing, designed to give unlimited travel constant accuracy and reduction of feed power, is available from Tycho Mfg. Co., Dept. S/A, 561 Hillgrove Ave., P.O. Box 406, La Grange, Ill. This data illustrates typical assemblies and gives specifications, applications, and lubrication sealing requirements.

Write in No. 375 on Reader Service Card

master reference gyros, which are centralized gyroscope systems, has been prepared by S.G. Brown Ltd., Dept. S/A, Shakespeare St., Watford, Hertfordshire, England. The system replaces the gyromagnetic compass, artificial horizon, and directional gyro, and provides attitude and azimuth reference as well for other systems. A 15-page booklet covers the Mark 1 model, and an information sheet is available on the more recent Mark II.

Write in No. 376 on Reader Service Card

more on page 282



Meet your needs for LONG FLEX LIFE with hose of Du Pont TFE resins



Hose lined with Teflon TFE resin, with its long ex life and resistance to heat and corrosion, bund many applications in the fuel and hydraulic ystems of Lockheed's prop-jet ELECTRA.

EFLON is Du Pont's registered trademark for s fluorocarbon resins, including the FE (tetrafluoroethylene) resins discussed herein.

Hose lining of Teflon TFE-fluorocarbon resins displays excellent endurance under conditions of continuous flexing, torque and vibration. This is just one of the ways in which the unique combination of properties offered by TFE resins can help you meet the rigorous requirements imposed on hose lines by modern flight equipment. TFE resins are rated for continuous use up to 500°F. Its toughness and flexibility permit the construction of lighter-weight hose for equivalent pressure ratings, with the resulting valuable weight saving. With overbraiding, hydraulic line pressures up to 6,000 psi are being achieved. Teflon is unaffected by all fuels, oils and hydraulic fluids, an important factor in safety and reduced maintenance.

Little wonder that hose lined with TEFLON TFE resins is standard equipment for fuel and hydraulic lines in many modern aircraft. Why not find out more about the properties of these unique resins, and how they can provide maximum safety and reliability with minimum weight and maintenance in your hose lines? Write to your local supplier or E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept., Room 80, Du Pont Building, Wilmington 98, Delaware.

In Canada: Du Pont of Canada Ltd., P.O. Box 660, Montreal, Quebec.





new engineering bulletin

Free data on sprayed coatings of metals and ceramics

Continuing developments in spraying equipment and materials, both metals and ceramics, are creating many opportunities for the design engineer to take advantage of the special properties of these coatings to improve wear resistance, abrasion resistance, heat resistance, corrosion resistance, for weight reduction and lowered production costs.

typical applications

Jet Engine Starter

Interior surfaces of exhaust-duct and combustion-chamber assemblies of jet starter engines are being protected by coating with alumina. This provides a thermal barrier to prevent creep and deformity of the chamber during the 1500° F. operating cycle.

Rocket ring mounts

030" thick coating of alumina protects laminated plastic ring mount against rocket blast during firing cycle; more than meets specifications.



Torque tube

Aluminum torque tubes, used in control of aircraft trim tabs are hard-surfaced with stainless steel over molybdenum at press-fit bearing sections.

free bulletin

Eight-page Engineering Data Bulletin No. 136 provides engineering data on sprayed coatings of metals and ceramics; illustrates and details typical application and provides a complete round-up of latest developments in equipment and materials as well as their characteristics. Use the handy coupon below.



Metallizing Engineering Co., Inc.

1133 Prospect Ave., Westbury, N. Y.

Please send me free Bulletin 13	6.
Name	Title
Company	
Address	
City	Zone State

Write in No. 312 on Reader Service Card at start of Product Preview Section

CABIN AIR CONTROLS—A collection of technical descriptions of aircraft cabin atmosphere control equipment, including pressure, temperature and humidity devices, among others, has been published by Normalair, Ltd., Dept. S/A, Yeovil, England. The equipment is available for both commercial and military aircraft. Also published is a catalog entitled, "The Best of Two Worlds," which deals with air conditioning equipment for aircraft.

Write in No. 377 on Reader Service Card

MICA ISOLATORS—The contribution to transistor reliability made by mica wafers used as isolators in heat sink applications has been described in Data Sheet K-5, available from Perfection Mica Co., Dept. S/A, 1322 N. Elston Ave., Chicago 22, Ill. The eight-page publication contains 29 outline drawings of available mica wafer shapes.

Write in No. 378 on Reader Service Card

MILITARY FACILITIES—A new, 28-page, illustrated, two-color booklet describes the military facilities, personnel, and equipment used for research, analysis, design, development, testing, and production at Singer Mfg. Co., Dept. S/A, 149 Broadway, New York 6, N.Y. Quality control is emphasized.

Write in No. 379 on Reader Service Card

ACCESSORIES—Data sheets on aircraft accessories such as actuators, switches and motors have been included in a catalog prepared by Western Mfg. (Reading), Ltd., Dept. S/A, The Aerodrome, Reading, Berkshire, England. Linear and rotary actuators are contained in the line, as are microswitches and special purpose motors.

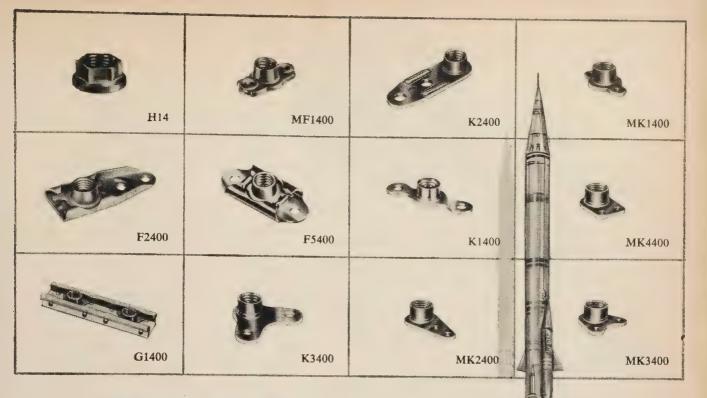
Write in No. 380 on Reader Service Card

AIRBORNE INSTRUMENTS—Burton Mfg. Co., Dept. S/A, 2520 Colorado Ave., Santa Monica, Calif., offers a catalog package, containing a folder and 13 engineering bulletins describing its complete line of airborne instruments and components. Specifications, applications, and dimensional drawings are given.

Write in No. 381 on Reader Service Card

ANTENNAS—A revised and expanded second edition of its Antenna Handbook has been published by I-T-E Circuit Breaker Co., Dept. S/A, 1900 Hamilton St., Philadelphia 30, Pa. The 28-page publication, which is designed for engineers concerned with radar and microwave antenna systems, includes detailed material for making mathematical conversions and for estimating performance and physical antenna characteristics.

Write in No. 382 on Reader Service Card more on page 284



Here's real

FASTENER POWER

KAYLOCK: 160,000 PSI

It's here...a powerful, new Kaylock line...now a whopping 160,000 psi! Smallest, lightest, strongest all metal self-locking nuts ever made. Tailor-made by KAYNAR for 160,000 psi NAS high tensile short thread screws and bolts.

Latest addition to the KAYLOCK line is the H14 lightweight hex...best wrench clearance for narrow flanges mightiest lightweight yet!

NEW H14 SAVES MOST IN SPACE • SIZE • WEIGHT

STRONGER — Strength to weight ratios increased up to 210%

LOWER — Same low height as NAS 679.

LIGHTER -20% to 67% below H10 or NAS679 series hex nuts.

SMALLER — By 2 to 5 socket sizes than standard AN and NAS nuts.

SPACE SAVER — Narrowest flanges. Moves bolt close to load centers for strongest design.

SELF-LOCKING -With patented resilient locking principle

MATERIALS -Available in carbon steel for 550°F, applications.

These configurations also in AMS6304 and A286 corrosion resistant steel.



FOR COMPETITIVE REASONS reappraise your projects with an eye to "trimming off the fat." Send today for Kaynar's new full-line brochure of 160,000 psi self-locking nuts.

World's largest and oldest manufacturer of lightweight, all metal self-locking nuts. Home office and plant: Write Box 2001, Terminal Annex, Los Angeles 54. Branch offices, warehouses & representatives in Wichita, Kansas; New York, N.Y.; Atlanta, Georgia. Canadian Distributor: Abercorn Aero, Ltd., Montreal, Quebec.

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Wickwire Aircraft Control Cables and Wickwire Rope for aircraft tiedown systems are sold through



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For your ordering convenience and quickdelivery needs, Air Associates Division of Electronics Communications, Inc. maintains large stocks of Wickwire Wire Rope in warehouses located at or near airports.

For the best in quality and service, order Wickwire Rope through the nearest Air Associates warehouse.

6932

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ANCHOR BUSHINGS - Brochure 2-809 describing press-type anchor bushings for drill templates has been issued by Hi-Shear Rivet Tool Co., Dept. S/A, 2600 W. 247 St., Torrance, Calif. The drill sizes accommodated by the bushings include #55 through 1/16.

Write in No. 383 on Reader Service Card

MERCURY "STATS"-Liquid temperature sensing thermostats are described in Bulletin 676 by Vap-Air Aeronautical Products Div., Vapor Heating Corp., 6420 W. Howard St., Chicago 48, Ill. It shows typical circuits, response curves, and contact tolerances for aircraft and missile applications.

Write in No. 384 on Reader Service Card

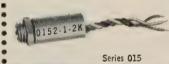
PRODUCTION STANDARDS—Data on all the standards for tool, die, jig, and fixture design and applications has been compiled in a catalog by Jergens Tool Specialty Co., Dept. S/A, 712 E. 163rd St., Cleveland 10, Ohio. It gives complete specifications and cost-saving data on over 2,000 "standards."

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more on page 286

Trimming POTENTIOMETERS and Variable RESISTORS







PACKS MORE POWER ... MORE RESISTANCE... MORE RELIABILITY ... INTO LESS SPACE!

... Compare CON ELCO potentiometers ... you'll find these quality controlled, precision instruments exceed all trade demands of miniaturization, reliability, resolution, vibration, shock, acceleration, humidity . . . and extreme environmental operating conditions.

CON ELCO provides instruments to fit every design standard, offers more power per cu. in. Ratings available up to 2.75 watts, with operating temperature ranges as high as -55°C to +180 °C. Standard resistances from 10 Ω to 125 K Ω (Many higher resistances available).

Available immediately in seven different sizes and configurations for chassis, panel or printed circuit mounting. Insulated stranded wire leads, solder lugs or printed circuit pins simplify packaging.

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Best Suited" for HIGH TEMPERATURES

VARGLAS SILICONE CLASS H

TUBING and SLEEVING

for applications requiring prolonged heat endurance at temperatures up to 260°C.

Varglas Silicone tubing and sleeving were developed by Varflex for applications involving continuous operating temperatures up to 260°C. Exceptional stability is combined with the following qualities...

Flexibility —Sharp turns and 90° bends cause no cracking or peeling—no loss of dielectric strength.

Dielectrically-Strong—All Grades conform to NEMA and MIL-I-3190 Standards.

Moisture-Resistant —including resistance to salt water, mild alkalis and acids.

Flame-Resistant—Standard burning test is 45 seconds to burn 1 inch. Can be made self-extinguishing on special order.

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Send for FREE SAMPLES Write today for free folder containing 25 dif-ferent test samples of Varflex insulating sleev-ing, tubing, lead wire and tying cord.



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Electronic signals that report the truth, the whole truth, and nothing but . . . wring the best performance from missile systems. By pushing beyond known capabilities in sensitivity and accuracy, Texas Instruments is producing "high IQ" systems and equipments for a dozen guided vehicles used in every basic mission: air-to-air, air-to-surface, surface-to-air, surface-to-surface — IRBM and ICBM—plus drone sensors and satellite instrumentation. TI exceeds tough specs against tight deadlines, regularly . . . specs asking solutions to problems never posed before. For detailed discussion, cleared personnel please write or call: SERVICE ENGINEERING DEPARTMENT.

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APPARATUS DIVISION



NSTRUMENTS

Tops in reliability!



Used in seven successful missiles. Union Miniature Relays originally were developed for air-borne and guided missile electronic equipment; they meet or exceed the requirements of MIL-R-25018, MIL-R-6106C, and MIL-R-5757C. They are now being utilized in the following missiles: The Matador, Thor, Talos, Vanguard, Atlas, Titan, and the Jupiter C.

The excellent reliability and small size of the Union Miniature Relays have led to their use in traffic control systems, computers, resistance welders, and other equipment.

OUTSTANDING FEATURES

HI-LO CONTACTS—Permit high and low load handling in same relay. Dry-circuit contacts available for extremely low-level loads.

COIL RESISTANCE—In standard case, from 0.9 to 8750 ohms; in long case, from 1.6 to 13,000 ohms.

TEMPERATURE RATING—Class A -55 to +85°C; Class B -65 to +125°C.

AC OR DC—Nominal operating voltages from 1.5 to 160 volts, DC; 115 volts, 60 to 400 cps, AC. Built-in rectifiers in AC relays.

TYPES AND MOUNTINGS—6PDT or 4PDT; plug-in or solder-lug connections. All usual mountings.

SPECIALS—Slow-acting relays if you need a differential between operating time of various relays. Plate-circuit relays—operate on less than 8 milliamperes; double-coil relays—either coil operates relay. Write for complete information.

See us at the Wescon Show-August 18-21-at Booth #2613-2615

"Pioneers in Push-Button Science"

UNION SWITCH & SIGNAL

DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY ——
PITTSBURGH 18, PENNSYLVANIA

Write in No. 317 on Reader Service Card at start of Product Preview Section

MISSILE SYSTEMS—Current specialized projects are among the factors considered in an eight-page brochure issued to present the missile system development and production facilities of Ford Instrument Co., Dept. S/A, 31-10 Thomson Ave., Long Island City 1, N.Y. Components for many advanced missiles are described, as

are engineering and test facilities.

Write in No. 386 on Reader Service Card

SERVO AMPLIFIER—Data Sheet A 3105-02 has been issued to describe a completely transistorized miniature servo amplifier made by Kearfott Co., Inc., Dept. S/A, 15500 Main Ave., Clifton, N.J. The lightweight unit delivers a maximum 2.5 W, and it is highly resistant to shock and vibration conditions encountered in high-speed aircraft and missile applications.

Write in No. 387 on Reader Service Card

X-RAY TESTING—Both laboratory and mobile non-destructive testing services have been described in a 12-page booklet prepared by Palmer Aero Products, Ltd., Dept. S/A, Penfold St., Edgeware Rd., London N.W.8, England. Gammaray and X-ray testing are used for metals, plastics, fabrications, and assemblies.

Write in No. 388 on Reader Service Card

DATA SYSTEM—Four displays that provide the flight information normally presented by ten conventional instrument dials are used in an advanced flight data system described in a 32-page brochure issued by Kelvin Hughes (Aviation), Ltd., Dept. S/A, Winchester Rd., Basingstoke, Hampshire, England. The displays offer height, speed, altitude and navigational data.

Write in No. 389 on Reader Service Card

RADAR TESTER—A booklet that contains operational and other pertinent information on the AN/GPM-25 radar system tester has been published by Mechanical Div., General Mills, Dept. S/A, 1620 Central Ave., Minneapolis 13, Minn. The tester, which uses radiated energy, offers a simplified method for rapid testing and evaluation of the operational capabilities of aircraft radar systems.

Write in No. 390 on Reader Service Card

ELECTRIC DEVICES — The Condulet line of conduit fittings and enclosures, and floodlights include types applicable to the missile field, according to an eight-page brochure prepared by Crouse-Hinds Co., Dept. S/A, Syracuse 1, N.Y. The units are available for both non-hazardous and hazardous areas, and they are made in explosion-proof models.

Write in No. 391 on Reader Service Card

CONNECTORS—A 36-page catalog has been used to describe the subminiature and miniature coaxial connectors, splices and printed circuit pin sockets available from The Nugent Electronics Co., Inc., Dept. S/A, New Albany, Ind. Dimensions, characteristics, and assembly instructions are included.

Write in No. 392 on Reader Service Card

DIAPHRAGMS—Diaphragms in capsule or stack form for the sensitive elements of pressure-indicating, recording and controlling instruments have been described in List A/15/1 by Negretti & Zambra, Ltd., Dept. S/A, 122 Regent St., London, W.1, England. The diaphragms are made of sheet material in suitably hard and springy condition, and stacks are self-supporting under the pressure and loads for which they are designed.

Write in No. 393 on Reader Service Card

MISSILE VERTICAL GYRO—Data Sheet 116-9, available from Lear, Dept. S/A, 110 Ionia Ave., N.W., Grand Rapids, Mich., describes and illustrates Series 1080 vertical gyros especially designed to give reliable operation in severe shock and vibration environments encountered in missiles, drones and high-performance aircraft, and includes engineering data and drawings.

Write in No. 394 on Reader Service Card

COMMUNICATIONS CONTROL—Information on the UA56 and UA57 aircraft communications control systems is available in an eight-page brochure published by Ultra Electric, Ltd., Dept. S/A, Western Ave., London W.3, England. The equipment provides a reliable intercommunications system control of several transmitters and receivers, and voice or radio range selection, as well as other services.

Write in No. 395 on Reader Service Card

AIR CONDITIONING—The latest developments in missile support air conditioning equipment are discussed and illustrated in a four-page brochure by C. G. Hokanson Co., Inc., Dept. S/A, 2140 Pontius Ave., Los Angeles 25, Calif. Specifications and characteristics are given.

Write in No. 396 on Reader Service Card

AUXILIARY POWER—A 40-hp turbodrive designed to provide electric and hydraulic power for high-speed, highaltitude, long mission space vehicles is discussed in Publication GET-2798 by General Electric Co., Dept. S/A, Schenectady 5, N.Y. The eight-page description covers operation, specifications, components, and/control system, and it includes specific fuel consumption charts.

Write in No. 397 on Reader Service Card more on next page



New UNION readout instruments withstand shock, vibration and extreme temperature changes

Union Switch & Signal's new READALL* readout instrument replaces complicated systems of lights and relays for reading, storing or transferring all types of information for industrial and military applications. It is not to be confused with conventional indicating devices.

Designed to meet requirements of MIL-E-5422D. The new READALL readout instrument is precision-built and provides instantaneous and continuous operation under conditions of shock, vibration and extreme ranges in temperature. The digital display includes characters in numerical sequence from 0 to 9 plus two blank spaces. %32-inch characters can be illuminated red or white as desired; when not illuminated, they appear white against a black background.

Reliability. Performance through one million random operations is an inherent feature of the new READALL instrument. Each module is gasket-sealed in its case to exclude moisture and seal out foreign particles. An especially thin enclosed DC motor, containing ball bearings, permits more efficient operation.

Modular Construction. A unique feature of the readout instrument is its modular construction. It can be used individually or in groups to display multiple characters in a single case.

Direct Code Translation. The operation of the READALL readout instrument is based on a positioning system using a four-bit code. The visual display is the result of a direct electro-mechanical conversion of a binary signal to a decimal read-out. There is no need for additional conversion equipment. Separate code and motor circuits permit the use of the readout instrument in low-level circuitry.

Electrical and Visual Data Storage. Once positioned, the information is displayed until a new code is transmitted to the instrument. No power is consumed while the information is retained. This data may be stored or read-out electrically for further transmission or recording.

Operate Time. The operate time varies from 0.1 second to 1.0 second depending on character position.

Weight and Size. Maximum weight including case is seven ounces; without case, four and one-half ounces. Size encased is 513/64 inches long, 147/64 inches high and 39/64 inch wide. The new READALL instrument is designed for operation over a temperature range of -54°C to +71°C in humidities up to 100% and altitudes up to 70,000 feet. For more information, write for Bulletin 1019.

See us at Wescon Show August 18-21 at Booths 2613-2615.

"Pioneers in Push-Button Science"

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DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY ——
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Convair B-58, Supersonic Bomber, test equipment is shown being checked out and installed in EMCOR Cabinets at Convair, a Division of General Dynamics Corporation, Fort Worth, Texas. The inset photo at top shows a portable preflight test unit for operational checkout of the Convair B-58 fire control system. The human engineering in EMCOR Cabinet design present a compact, centralized and interconnected control center which brings all equipment within easy reach and sight of the operator. EMCOR Standard Cabinets with their exclusive combination of patented custom quality features are proving themselves daily in major control center and production line applications.

WRITE TODAY FOR CATALOG 106

Originators of the Modular Enclosure System

DELGIN METALFORMERS CORP.
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VISIT OUR BOOTH 1819-1821 AT THE WESCON SHOW COW PALACE, SAN FRANCISCO, CALIFORNIA

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DC TACHODYNAMO—Type Sheet 134-27-2 E has been issued on the dc tachodynamo GD 506, a separately-excited dc generator made by Standard Elektrik Lorenz AG, Dept. S/A, Hellmuth-Hirth-Strasse 42, Stuttgart, Germany. The device is used as a measuring element in control and regulating systems, for speed-dependent variables, and it has a maximum speed of 5000 rpm and maximum load

Write in No. 398 on Reader Service Card

INSTRUMENT CASES—Catalog D, a 12-page, three-color, illustrated, loose-leaf type booklet, giving technical data on its military transit combination instrument cases, is available from Zero Mfg. Co., Dept. S/A, 1121 Chestnut St., Burbank, Calif.

Write in No. 399 on Reader Service Card

bata recording — A combined handbook and catalog on the completely integrated, and flexible Midas multi-channel system for data recording and analysis has been published by Royston Instruments, Ltd., Dept. S/A, Hanworth Lane, Chertsey, Surrey, England. The comprehensive publication deals with all components of the system, which will accept any known type of input and present any known type of output.

Write in No. 400 on Reader Service Card

TURNTABLES — Sterling Precision Corp., Dept. S/A, 229 Binney St., Cambridge 42, Mass., offers an engineering report, ER-140, containing specifications and drawings for its Model T848 12 in. Dia Rate Turntable. General information and features are discussed in this four-page report.

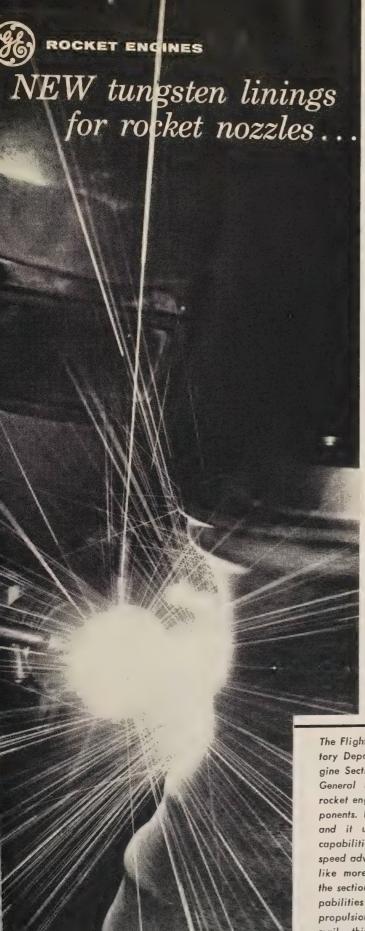
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RADAR BEACON—The RB110 radar beacon, which has a one-kw power output and can handle simultaneous interrogation from about 75 aircraft, has been described in a 4-page brochure by Murphy Radio, Ltd., Dept. S/A, Welwyn Garden City, Herts, England. Another brochure discusses the MR255 beacon control equipment, which provides automatic supervision of a transponder beacon such as the RB110.

GROUND SUPPORT EQUIPMENT—A variety of specially designed explosion-proof aluminum enclosures for electrical ground support equipment for the missile and aircraft industries are described in an illustrated brochure by Nelson Electric Mfg. Co., Dept. S/A, P.O. Box 5385, Tulsa, Okla.

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Write in No. 403 on Reader Service Card more on page 289



MELTING POINT: 6170°F.

Tungsten-lined lightweight nozzles for solid propellant engines are now being fabricated by General Electric. With a lining melting point of 6170°F, these are among the highest temperature lightweight fixed and flexible nozzles in use in the missile industry, enduring high rocket propellant temperatures and pressures with no measurable erosion.

These nozzles are produced by an arc-spraying process pioneered by General Electric. Tungsten is vaporized in an arc and deposited on a mandrel. For some applications, the liner is molded in lightweight plastic, and the mandrel leached out.

Arc-sprayed nozzles have been hot-fired with the new high temperature propellants at several locations.

G.E.'s capabilities in metallurgy and manufacturing are combined with equally advanced capabilities in engineering, research and development. Integrated advanced rocket engine capabilities at General Electric can meet your needs for high performance solid propellant engine cases, nozzles and liquid engine components using cryogenic and storeable propellants.

Progress Is Our Most Important Product

GENERAL (ELECTRIC

The Flight Propulsion Laboratory Department's Rocket Engine Section is the nucleus of General Electric progress in rocket engines and their components. It is well-equipped; and it uses Company-wide capabilities and experience to speed advances. If you would like more information about the section's products and capabilities in solid or liquid propulsion systems, please mail this coupon. Rocket Engine Section, General Electric Co., Cincinnati 15, Ohio.

Section N182-2 Rocket Engine Section Flight Propulsion Laboratory Department

General Electric Company Cincinnati 15, Ohio

Please send me additional information about General Electric solid propellant cases and nozzles (GED-3763).

I would like to discuss G-E rocket engine products with a sales representative.

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Company
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State



No one understands the extreme importance and value of vital test film better than CFI. For this very reason, our security system, devised to handle classified film, is the model for the industry.

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CFI's EXPERIENCE with many major aircraft and missile companies and related organizations enable us to recognize the need for uncompromising quality and fast action.

CFI FACILITIES are the finest.. complete and modern. Improved processing techniques are constantly being developed at CFI, advancing the state of the art.

CFI KNOW-HOW has been accumulated in its 40 years as the nation's largest and most progressive organization with complete lab facilities in both Hollywood and New York.

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CONSOLIDATED FILM INDUSTRIES 959 Seward St., Hollywood 38, Calif. . HO 9-1441 521 West 57th St., New York 19, N.Y. + Cl 6-0210

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DEMAND PUMP-Data Sheet WF 1642 gives features, applications, and specifications for its pump, Model 120-1. It was designed specifically for low flow applications. Data is available from Waldorf Fluid Systems, Waldorf Instrument Co., Dept. S/A, Wolf Hill Rd., Huntington Station, Long Island, N.Y.

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STATIC TUBE – Technical Bulletin #581, the first literature fully describing the characteristics of the MA-1 Pitol Static Tube is available from Waste King Corp., Dept. S/A, 4600 Pacific Blvd., Los Angeles 58, Calif. Applications, design, features, input power and surface temperature characteristics of the tube are described and diagrams, illustrations, and specifications are included.

Write in No. 405 on Reader Service Card

TESTING SERVICES—A complete line of laboratory and field testing facilities and services have been described in Bulletin 5801, available from United States Testing Co., Inc., Dept. S/A, 1415 Park Ave., Hoboken, N.J. The bulletin discusses the engineering facilities and services necessary to a diversified testing program, which includes environmental studies, instru-ment calibration, materials testing, and others.

Write in No. 406 on Reader Service Card

TEMPERATURE-MY CONVERSION— Temperature-millivolt conversion ta-

bles in compact chart form have been made available by Thermo Electric Co., Inc., Dept. S/A, Saddle Brook, N.J. The chart converts Fahrenheit and Centigrade temperatures, in fivedeg increments, to my values for eight different thermocouple calibrations.

Write in No. 407 on Reader Service Card

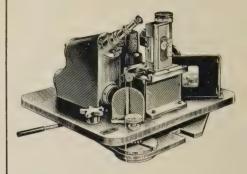
FACILITIES-A 24-page booklet on it research, engineering and manufacturing facilities for military and industrial systems has been issued by Mechanical Div., General Mills, Inc., Dept. S/A, 1620 Central Ave., Minneapolis 13, Minn. Guidance and navigation development, weapons and reconnaissance systems, and communications and controls development are among company interest.

Write in No. 408 on Reader Service Card

MOTOR GENERATOR-The Model 40 SG 50, a motor-generator set designed for ground power support of missiles and jet aircraft, has been described in the two-page Bulletin 2600-PRD-257 by Electric Machinery Mfg., Co., Dept. S/A, Minneapolis 13, Minn. The unit has a separate cubicle to house all control components, and it is rated to deliver 50 kw of 400-cycle power.

Write in No. 409 on Reader Service Card

OPTICAL STRAIN-MEASURING INSTRUMENT



Tests tensile properties of radioactive materials at reactor temperatures

This Optical Strain-Measuring Instrument was designed for nuclear reactor development work. It permits precise determination of the tensile properties of irradiated fuel and structural materials at reactor temperatures.

Gaertner Scientific Corporation, designers of the instrument, had this problem to overcome: extremely accurate measurement of elongation must be made even when the specimen itself is inaccessible due to radiation and temperatures up to 800° C.

To solve the problem, Gaertner developed a special mechanical-optical system to measure elongation of a specimen with direct reading to 50 micro-inches.

The optical system has a working distance of more than 24 inches, permitting the insertion of shielding between the optical unit and the furnace the light travels through six inches of lead-glass shielding and the quartz window of the furnace. This allows the operator to observe the specimen closely and yet be completely safe from radiation hazard.

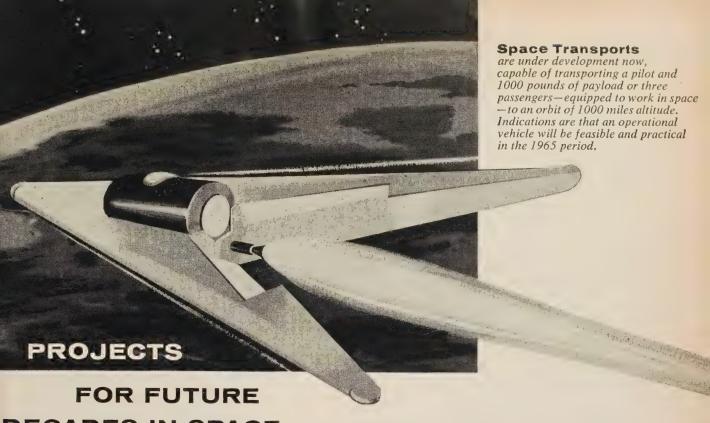
Wide range measurement is possible .. the micrometer moves through 0.5 inches for a one-inch specimen. This makes it possible to measure elongation-to-failure of many irradiated fuels and structural materials.

The Optical Strain-Measuring Instrument is one of many precision optical instruments designed and manufactured by Gaertner to measure dimensional changes of specimens under various environmental conditions.

Write for Bulletin 161

Gaertner 1270 Wrightwood Ave. Chicago 14, Illinois

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DECADES IN SPACE... another Lockheed Progress Report to Engineers

ting the nation's future space exploration projects ires the capabilities of a forward-looking company; with vision, superiority in technical skills and advanced ties. Lockheed, Burbank, long a leader in extending cience of flight, is placing its vast resources and accuted knowledge into programs designed to provide or breakthroughs in the fields of: Basic and applied arch; manned aircraft of advanced design; missiles and excraft. Shown here are artists' renderings of a few of a important projects. Such project diversification calls high-level technical skill, offers genuine challenge to rienced engineers. At Lockheed these varied projects are engineers in many fields. Take advantage of this a Go forward with a forward-looking company:

cheed, Burbank.

SUPERSONIC TRANSPORT

ersonic Transports—have held an important place thinking for the past several years. Extensive wind tunnel ave been conducted on many design concepts, supplemented austive laboratory and structure studies. Lockheed is preto build an airliner that will travel at speeds in excess of 3 at an altitude of 75,000 feet.

Infrared Systems studies are being conducted using an advanced method of detecting fast-moving missiles and high-speed aircraft. A new facility, which includes an advanced laboratory, with an infrared tunnel, for basic research and development of prototype equipment in this expanding field, has been set up to push Lockheed, Burbank, to the forefront in infrared study.



Vertical Take-off and Landing Projects—Lockheed, Burbank, is engaged in exploring the potential of VTOL projects on a very broad scale. Different VTOL features are embodied in each proposal. Considerable emphasis is being placed on VTOL "air recovery" vehicles, designed for air rescue and reentry missiles recovery missions.

Solar Radiation Studies—are being conducted at Lock-heed's flight test radio station at Briar Summit, California, placing particular emphasis on solar flares as our contribution to the International Geophysical Year. We have already accumulated more than a quarter of a million images of the sun for analysis. In cooperation with other companies, we will determine the processes by which solar energy is released.

High caliber scientists and engineers are invited to take advantage of Lockheed's outstanding career opportunities. Openings now exist in: Electronics; aero and thermodynamics; propulsion; servo-mechanisms; materials and processes; structures and stress; operations research; research in optics, infrared, acoustics, magnetohydrodynamics, instrumentation, mechanics and hydraulics; mathematics; and in all phases of design. Write today to: Mr. E. W. Des Lauriers, Manager Professional Placement Staff, Dept. 1908, 2400 North Hollywood Way, Burbank, California.

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Project: SALT WATER PUNCH
Filter Application: PROTECT HYDRAULIC CONTROLS

Filter: PUROLATOR

The Polaris and the nuclear powered submarines which will carry and launch it form a mobile striking force that commands respect. Wherever they may be, it is imperative that, when the signal is given, the Polaris takes off and goes straight to the target.

Hydraulic control circuits play an important role in the programmed flight of the Polaris. To insure against malfunctions in the circuits, Purolator filters are designed as

an integral part of many of them, to specifications set by Lockheed Missiles and Space Division, Polaris missile system manager.

Purolator engineers will gladly bring to your needs the filtration knowledge they provide for Polaris and other top-priority projects. A letter or phone call describing your aircraft or missile filtration requirements will receive prompt attention.

Filtration
For Every Known
Fluid

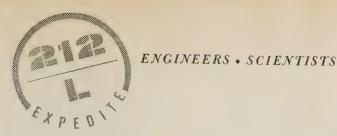
PUROLATOR

PRODUCTS, INC.

RAHWAY, NEW JERSEY AND TORONTO, ONTARIO, CANADA

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SPACE/AERONAUTICS



General Electric's Heavy Military Electronics Dept.

AWARDED CONTRACT FOR

Systems Integration, Engineering, and Management of...

AIR WEAPONS CONTROL SYSTEM 212L

<u>A universal electronic control system to meet the vast problem of Air Defense</u> <u>outside of the Continental United States</u>

Systems-oriented engineers and scientists will appreciate the broadband technical challenge of the Air Weapons Control System 212L. There are important openings for men who are experienced in: Weapons Systems Analysis • Mathematical Analysis of Engineering Problems • Computer Programming • Military Communication Systems • Radar Systems • Weapons Control Systems • Electronic Circuitry • Industrial & Military Psychology

■ Working in close cooperation with the USAF, it is Heavy Military's responsibility to integrate all subsystems—data acquisition, communications, data processing and display plus various defensive weapons into a well coordinated and efficient operating system.

VERSATILE AIR CONTROL APPLICATIONS The revolutionary 212L can be used to defend a single airfield, or, by linking control sites together, it could be used in a limited action to provide air control for an area the size of Alaska. Similarly, by linking the capabilities of countries together, a system could be provided for the air control of an en-

tire continent. Designed for both fixed and mobile applications, the 212L will be used primarily outside the U. S. since the SAGE system is used for the defense of this country.

HMED IS ALSO DESIGNING THE "HEART" OF THE SYSTEM

In addition to its prime mission of providing systems management, HMED will design, develop and produce the data processing and display subsystem which is the "heart" of the 212L. Capable of rapidly and automatically detecting and tracking air targets, the subsystem operates without human assistance, except under unusual circumstances.

OTHER FAR-RANGING PROGRAMS AT HEAVY MILITARY

At the present time additional far-ranging programs are being pursued in diverse and important areas at HMED:

- Fixed & Mobile Radar
- Shipborne Radar
- Underwater Detection Systems
- Missile Guidance
- Data Handling Systems
- Communications

Individuals with experience in systems analysis or specific equipment design in the areas listed above are invited to forward their resume in complete confidence to Mr. George Callender, Div. 60-MH.

HEAVY MILITARY ELECTRONICS DEPARTMENT

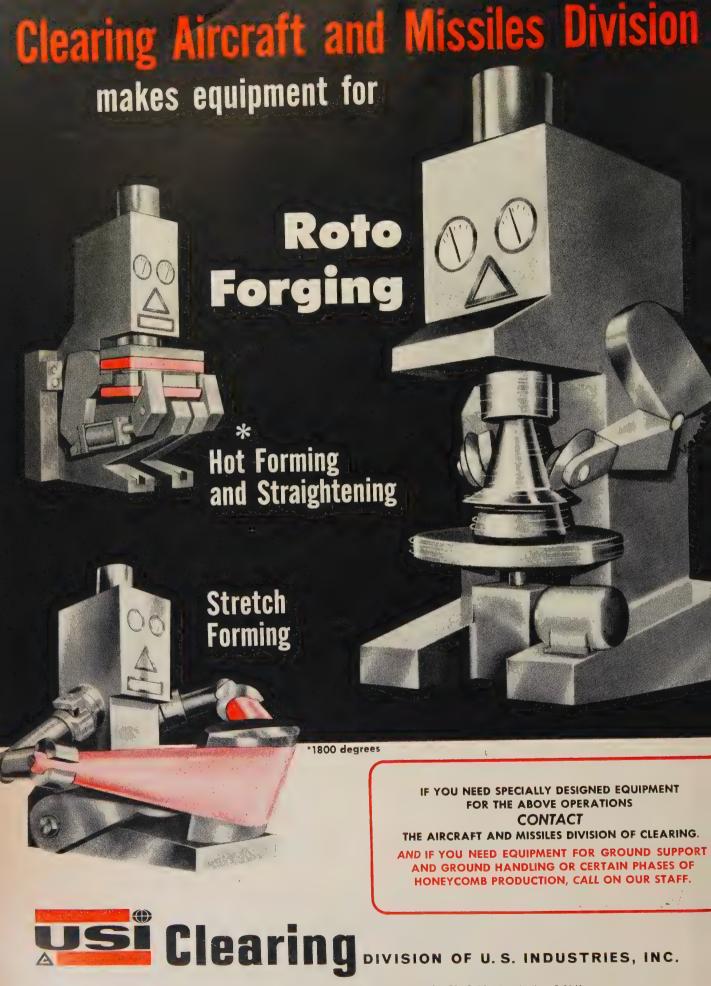




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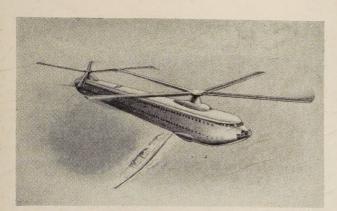


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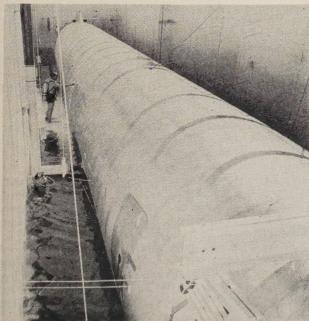
industry briefs



MULTI-DECK layout is foreseen for 500,000-lb, 200-mph-plus nuclear copter Bell says is feasible.

LIGHTWEIGHT GE J85 is being test-flown in a belly pod on a Convair F-102A interceptor.



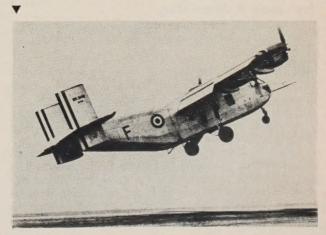




NEW LAUNCHER-ERECTOR for Convair Atlas ICBM will be installed at Warren AFB, Wyo., launch site.

■ SIX-MONTH pressure and load cycling tests on Convair 880 got underway with immersion of fuselage.

FIRST FLIGHTS were made by experimental Breguet-Piasecki four-engine STOL transport using superflaps.



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readers' round table

Shall we go to the metric system?

by E. O. Klimt,

Missile Engineering Div., McDonnell Aircraft Corp.

THE MAGNITUDE of this conversion should not be under-estimated. Where human nature is involved, it is difficult if not impossible to change certain things.

English to metric conversion is comparable to changing the face of a clock, or the keyboard of a typewriter. As you know, human engineering studies have shown the existing typewriter keyboard to be highly inefficient for the English language—but it has not been changed! Why?

While the conversion would be easy, and most beneficial to persons directly involved, i.e., scientists, engineers, mathematicians, one must also think of the "whole picture", i.e., changes in educational institutions, reference manuals, hardware, standards, and the business world and commercial applications.

Before deciding to change, one should thoroughly investigate not only the desirability but also the feasibility and efficiency of that change. This subject would be good material for thesis study, as a systems engineering study group, operations analysis type work. Organizations like Rand Corporation, Vitro, Armour, and McDonnell Aircraft could produce a worthwhile project on this problem.

Why don't you ask the government to fund this study? \$250,000 would do the job.

Look before you leap.

by Jean F. Duvivier,

Research Engineer, Aeroelastic & Structures Research Laboratory, Massachusetts Institute of Technology

W HENEVER the question of metric vs English/-American system comes up, it is usually on an emotional rather than a logical basis.

The more typical arguments run somewhat like this: It makes no difference what system you use. The English system also uses decimals.

Answer: This is hardly meaningful since decimal inches cannot be readily transformed into decimal feet (used only by surveyors) nor into decimal miles, nor can decimal pounds be easily converted into decimal ounces, etc, etc. Do we want a currency system in

pounds, shillings and pence, rather than 100 cents to the dollar?

Admitting the many advantages of the metric system, everybody here knows the English system and would have a hard time learning the metric system.

Answer: Not true—quite a few people do not know how many ounces make a pound or how many feet make a mile, besides having a hard time dealing with fractions. (How many square feet is the area of a rectangular nozzle $4^{13}/6 \times 5^{3}/2$ in.?)

As for ease of learning, the metric system is taught in European schools to 9 and 10-yr old children who learn it in a short time. Why should it be harder for adults?

It would be prohibitively costly to change industrial machinery to the metric system.

Answer: Not necessarily. The only change that would be required in many cases is that of gages and dials. And, since the workers who deal with them most of the time use gage blocks and scales to set up their work, it makes little difference whether the units are of one kind or another. However, mistakes caused by transforming fractional dimensions into decimals, or dealing with two sets of scales, etc. would be avoided.

In addition, many industries (including the machine tool industry) make special models for sale in metric countries, therefore having costly duplication of facilities and equipment.

Furthermore, since the average life span of machinery in this country before replacement is approximately 7-10 years, it would not be long before the normal attrition rate would take care of a gradual changeover without excessive expenditure.

I do not claim that there would not be problems, but I believe they would be far less serious than is often asserted, especially if the change is made gradually. We might as well face the fact that within the next 10-15 years the situation will be worse, rather than better, to start changing, with the additional competition for world markets, the increased challenge of the Communist empire, and the unnecessary waste and cost of a system that worked all right when the stagecoach was the most advanced means of transportation.

The foot, pound, inch, league, etc., existed in every European country until 50 to 80 years ago. One after another, every industrial country in the world but England and the United States has changed to the metric system. There must be some good reasons.



Because his motor control system is inadequate to "orbital" conditions, the happy fellow above may well feel more than a little "out of this world". His old familiar muscles are incapable of providing the precise, reliable control he needs.

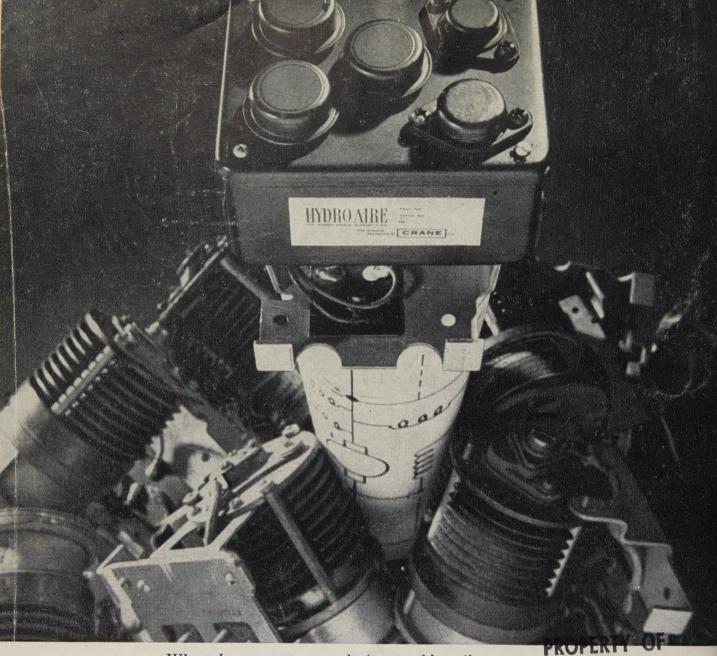
So it is with the new generation of high-speed air and space vehicles. More and more, hydraulic servomechanisms are giving way to a variety of hot gas actuator systems, relatively insensitive to high ambient temperatures and in many ways ideally suited to such requirements as space-age vector and vernier control.

Chandler Evans has been conducting a number of research and development programs in the field of high-pressure pneumatics. As a result of its extensive feasibility studies, CECO is now prepared to discuss with you the merits of systems which feature the use of chemically generated gases derived from either solid or liquid propellants.

HANDLER EVANS CORPORATION WEST HARTFORD 1, CONNECTICUT

For a new folder on CECO hot gas actuator systems, address your request to Department 49.





When d-c generator regulation troubles pile up... CHICAGO MIDWAY LABORATO Specify Hydro-Aire's new transistorized voltage regulator

Hydro-Aire's new, completely transistorized regulator for d-c generators weighs less than half as much as the conventional carbon-pile regulator that it replaces. Response time is five times better, and operational life is extended to 10,000 hours. The new Hydro-Aire units are physically and functionally interchangeable with MIL-standard carbon-pile regulators - plug directly into existing receptacles.

Other important features of the new Hydro-Aire unit: Has no moving parts, requires no shock mounting, dissipates virtually no heat, requires no forced cooling, adjusts easily to different voltages.

Model 50-029 (shown above) has these characteristics:

Voltage: may be set to any value between 26 and 30 volts, in increments of 0.1 volt. Temperature limits: -55°C to +71°C Rated life: 5000 hours without maintenance Dimensions: 31/4 x 41/8 x 27/8 inches Weight: 11/4 pounds

Additional ratings are available and our laboratories welcome the opportunity to design new devices to your specific requirements.

Write or wire for complete information on Hydro-Aire's generator regulators, and other solid-state devices.

Producing Controls for Every Basic Airborne System



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